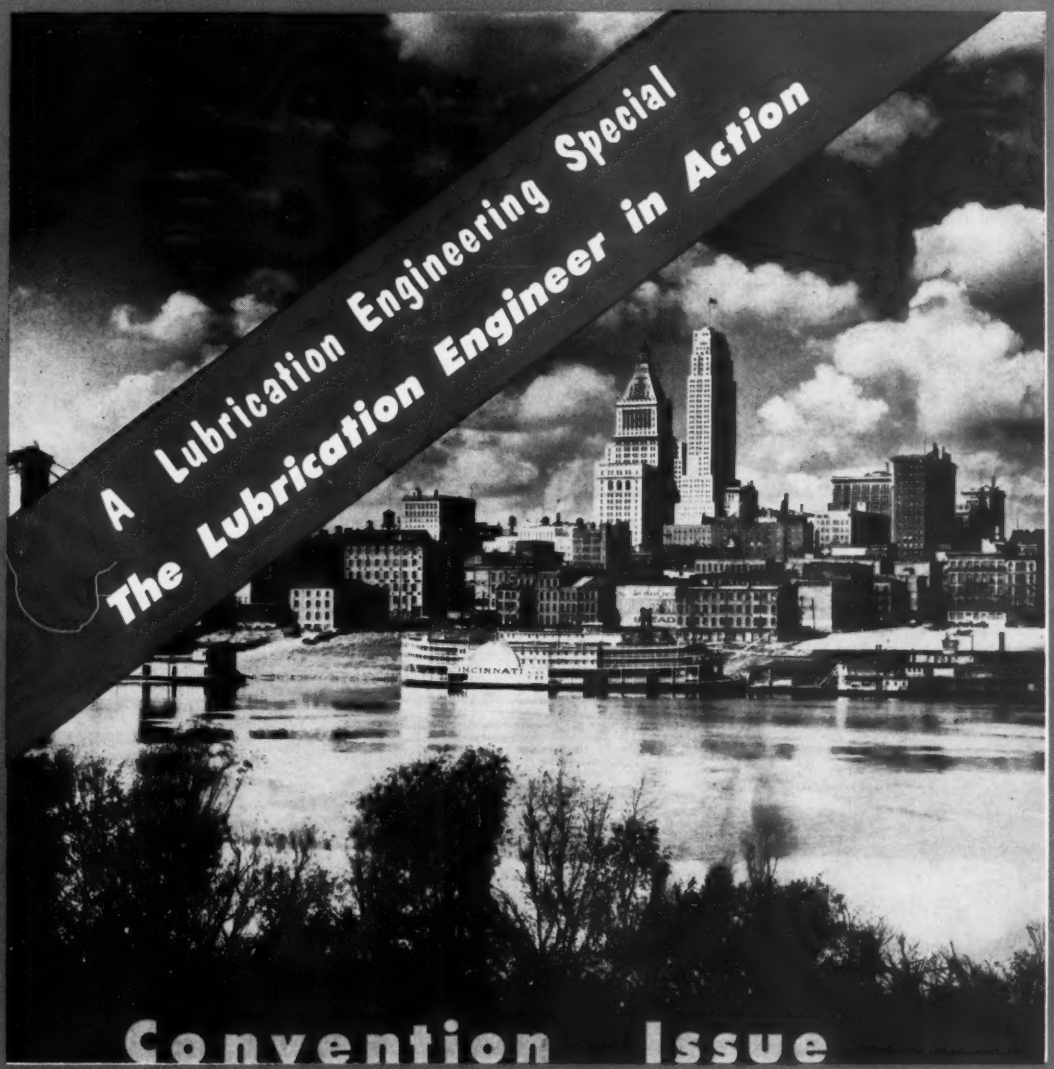
Vol. 16, No. 4 April, 1960

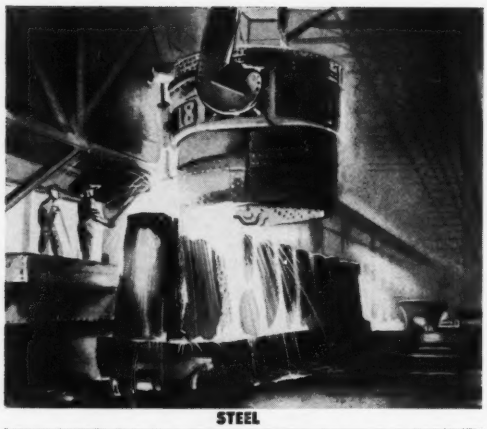
LUBRICATION ENGINEERING

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE



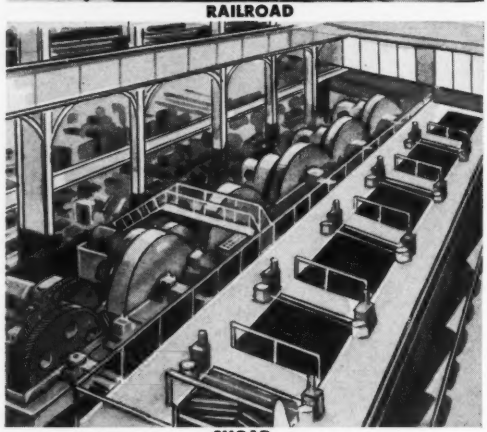
JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Wherever Lubricants are used!

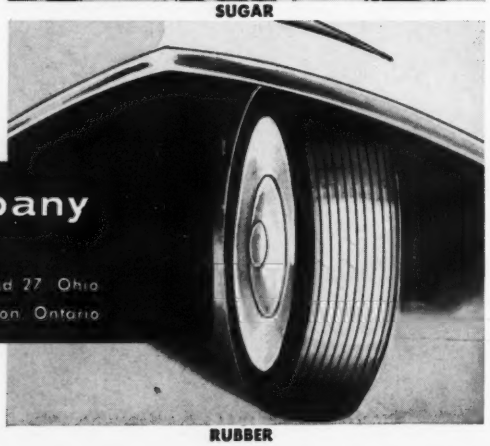


STEEL

RAILROAD



SUGAR



RUBBER

For 84 years, The Brooks Oil Company has supplied superior lubricants to industry throughout the United States and Canada.

In severest applications Brooks lubricants maintain a friction-resisting film where ordinary lubricants fail, and they continue to give completely satisfactory service for long periods of time. The result is better lubrication at less cost.

Brooks plant, laboratory and research facilities, technical and engineering services are among the most modern and efficient to be found in this highly specialized lubrication field.

Lubrication of industrial equipment is our specialty.

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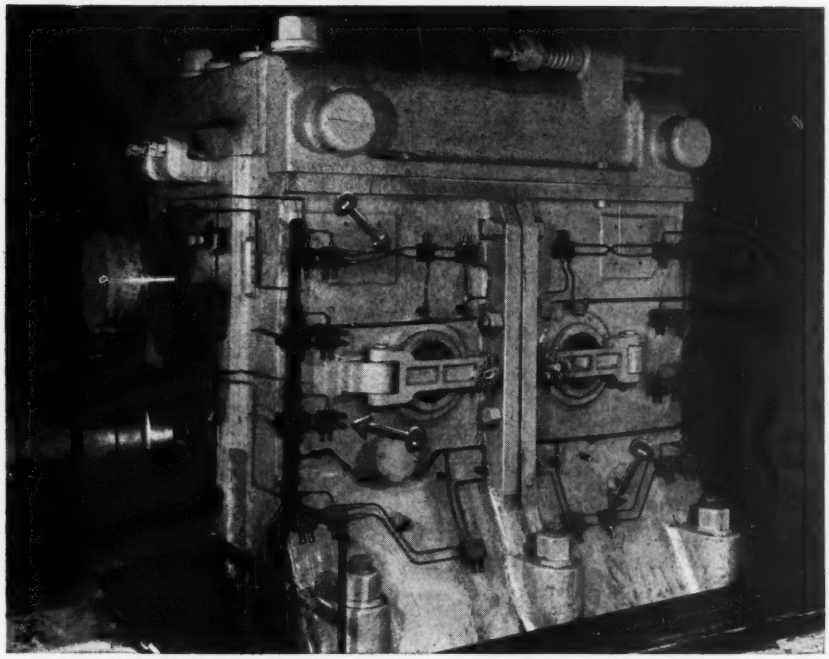

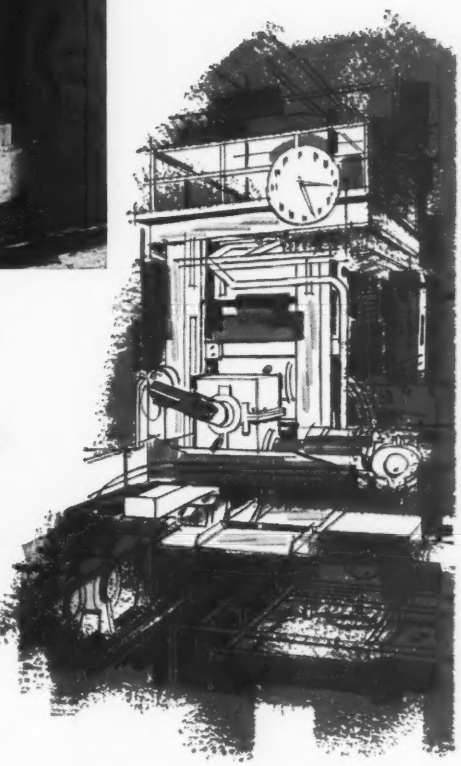

Farval lubrication helps keep Acme Steel's blooming mill on 'round-the-clock operation

Here's the delivery end of a recently installed Farval air-operated time clock-controlled spray system. It provides dependable 'round-the-clock lubrication at 18 points for the internal gearing in this new blooming mill pinion stand at Acme Steel Company, Riverdale, Illinois. An engineered overflow arrangement returns the lubricant back to an air-operated barrel pump attached to a 400-pound drum.

Throughout Acme Steel's expansion program, eleven Farval systems are busy at work lubricating vital bearings on all types of production equipment . . . Steel plant engineers know from experience that Farval Dualine Lubrication Systems

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- Save Both Labor and Lubricant
- Enhance Good Housekeeping
- Keep Machines Operating Continuously
- Eliminate Hazardous Hand Lubrication

No wonder virtually every major steel producer chooses Farval for their heavy-duty lubrication requirements.

Get the complete cost-cutting story from your Farval representative—or write today for free revised Bulletin 26-T.

KEYS TO ADEQUATE LUBRICATION
—wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and pump stations—you know rolling mill equipment is being properly lubricated.

Farval Studies in Centralized Lubrication No. 250

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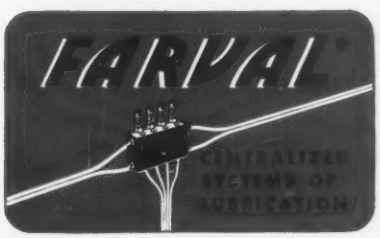
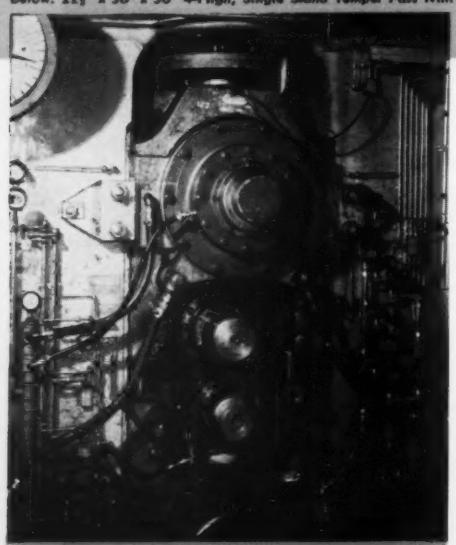


MORGOIL
BEARINGS

Above: 21" x 56" x 56" 4-High, 4-Stand Tandem Cold Strip Mill
Below: 22½" x 56" x 56" 4-High, Single Stand Temper Pass Mill



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MB 38

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The demonstrated ability to meet high speeds, heavy loads and close tolerances made MORGOILS a natural choice for the back-up rolls on Inland Steel's new Cold Mills at the Indiana Harbor works.

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MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS
ROLLING MILLS • MORGOIL BEARINGS • WIRE MILLS
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Volume 16, No. 4
April, 1960

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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LABORATORY REPORT

Testing proves Baragel and Baragel* 24 grease effectiveness*

BARAGEL grease tests being conducted continuously

Tests are constantly being conducted using BARAGEL and BARAGEL 24 in greases made from both petroleum and non-petroleum base oils. The greases are formulated from refined oils of varying viscosities with selected dispersion aids.

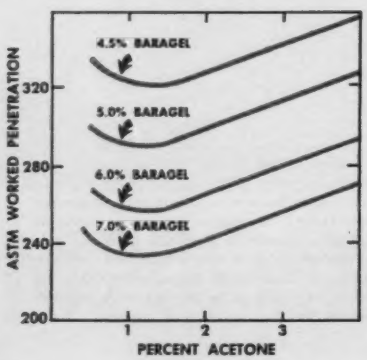
BARAGEL and BARAGEL 24 are versatile, non-soap grease gelling agents consisting of mixed organic ammonium halides and refined sodium montmorillonite. Test results are available in printed form. If you are not already on the mailing list, you can obtain Data Sheets by writing Baroid Chemicals, Inc.

BARAGEL very versatile in greases made with oils of varying viscosity indexes

BARAGEL is considerably more efficient than BENTONE* 34 in greases compounded with solvent refined, high VI oils. Greases having an ASTM worked penetration in the 315 range require about 4.5% BARAGEL compared to a BENTONE 34 requirement of about 5.75%.

BARAGEL has also proved to be efficient in greases compounded with conventionally refined oils of relatively low viscosity index. Tests were made with a base oil of 21.5° API gravity and a viscosity of 517 SUS at 100° F.

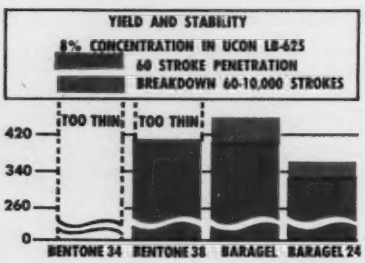
BARAGEL was stirred into the oil, acetone added and stirred, and the mixture was milled. Greases having an ASTM worked penetration in the 315 range required about 4.5% BARAGEL, while greases in the 280 range required about 5.5% BARAGEL. Data Sheet A-3, available on request, gives full details of this test.



Greases made with Ucon LB-625

BARAGEL 24 is more efficient in thickening Ucon LB-625 than are BENTONE 34, BENTONE* 38 and BARAGEL. BARAGEL 24 greases are also more stable to working in the ASTM grease worker.

In a series of tests, the gelling agents were stirred into the Ucon LB-625, propylene carbonate was added, heat applied, and the mixture



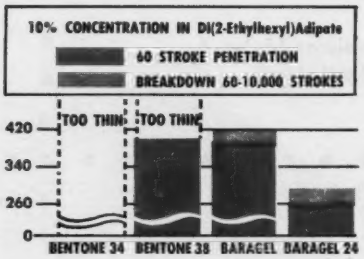
was milled. The chart above compares the results of thickening greases with BENTONE 34, BENTONE 38, BARAGEL and BARAGEL 24. Full details of these tests are available in Data Sheet A-1.

The worked penetration of a grease made from Ucon LB-625 and 8% BARAGEL 24 was 315, with a penetration of 355 after working 10,000 strokes.

BARAGEL 24 efficient in greases made with Di(2-Ethylhexyl) Adipate

BARAGEL 24 has been proved by tests to be particularly efficient in thickening greases made with Di(2-Ethylhexyl)Adipate. Greases prepared with BARAGEL 24 are also much more stable to working in the ASTM grease worker.

Tests were made to compare results when thickening greases with BENTONE 34, BENTONE 38, BARAGEL and BARAGEL 24. The results are shown in the accompanying chart and



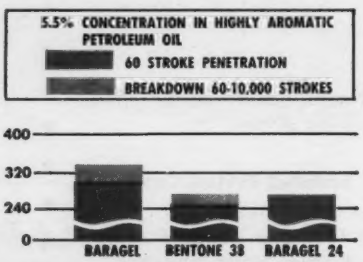
details are available in Data Sheet A-2.

Greases made with Di(2-Ethylhexyl)Adipate and 10% BARAGEL 24 showed worked penetrations of 260. After working 10,000 strokes, these same greases showed a penetration of only 290.

BARAGEL 24 in grease made with petroleum oil

In a particular petroleum oil of high aromatic content (28%), BARAGEL 24 produces a grease completely stable to working in the ASTM grease worker over the range of unworked to 10,000 strokes.

In a series of tests, the oil used had an API gravity of 16.9° at 60° F and a viscosity of 309 SUS at 100° F. The worked penetration was 265 when 5.5% BARAGEL 24 was used. Comparisons of penetration when using the same per cent of BENTONE 34 and BARAGEL are shown on the accompanying chart. Full details are available in Data Sheet A-4.



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LUBRICATION IN THE NEWS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

BEST, GRECO, GRIBBLE ELECTED TO NACE OFFICES

New officers have been elected to head the National Association of Corrosion Engineers for the period beginning March 1960 and ending March, 1961. George E. Best, Manufacturing Chemists' Association, Washington, D. C., will be president. Edward C. Greco, senior research chemist of the research department, United Gas Corp., Shreveport, La., is vice president elect and C. G. Gribble, Jr., district manager for Metal Goods Corp., Houston, Texas, will become treasurer.

Also elected were three directors, each for 3-year terms. They are: J. S. Dorsey, Southern California Gas Co., Los Angeles, Cal., and J. E. Rench, Napko Corp., Houston, corporate representatives and T. J. Maitland, American Telephone and Telegraph Co., New York, N. Y., active member representative.

Newly elected officers will be installed on the last day of the 16th Annual NACE Conference, Dallas, March 14-18, 1960.

(Source: National Association of Corrosion Engineers)

NEW SOCIETY FORMED

A new technical organization—the Fluid Power Society—has been formed to bring together all persons interested or engaged in any activity which may further the development and use of fluid power and the dissemination of knowledge pertaining to it or related subjects. Its formation is a result of collaboration over the past year between the National Fluid Power Association and the Industrial Hydraulics Training Association. The National Fluid Power Association, formed in 1953, is the trade association for the industry and only companies are eligible for membership therein. The Industrial Hydraulics Training Association was organized in 1957 to bring together a group of instructors of industrial hydraulics in the Detroit area for educational purposes.

Qualifications for membership in the Fluid Power Society are not restrictive. This is intentional in order to bring together persons interested in all phases of the general subject—research, development, application, design, installation, operation, maintenance and education—and serving all fields of utilization—industrial, aviation, marine, mobile, material handling, agricultural implements, etc.

Membership is on an individual basis, but the Society will carry on its principal activities through local Chapters which will be given much latitude in determining their local fields of interest. It is expected that some Chapters will contain several sections; and that in some of the larger cities there will be more than one Chapter, each specializing in a different major interest.

The first meeting of the Fluid Power Society will be held at the Statler Hilton in Detroit on April 21 when members of the Industrial Hydraulics Training Association will be chartered as Chapter No. 1. Persons not affiliated with IHTA are invited to attend the meeting. Chapter No. 2 is being formed in Milwaukee. Other applications are pending. It is expected that by the end of 1961 there will be local units in all of the principal cities in the United States and Canada.

For further information, contact Barrett Rogers, Executive Vice President, National Fluid Power Association, 5595 North Hollywood Avenue, Milwaukee 17, Wisconsin.

(Source: National Fluid Power Association)

NEW MOTOR OIL TEST REPORTED

Oronite Chemical Company, a subsidiary of the Standard Oil Company of California, reports it is now using a new, unusually accurate laboratory test procedure to predict low temperature field performance of compounded motor oils.

Data to establish the new procedure's correlation with extended in-engine use were obtained from more than eight million miles of road testing in various types of automotive engines—including several fleets of taxicabs. The road tests were carried out over a ten-year period in every type of weather and driving condition.

With such comprehensive data, the Company reports, the excellent correlation of road performance with the new laboratory test procedure has been definitely confirmed. Additional data, now being gathered, is expected to reconfirm earlier findings.

The new laboratory test procedure, developed by Oronite's research affiliate, California Research Corp., is actually a modification of a standard 40-hour, FL-2 engine test devised by the Coordinating Research Council. Performance of the test oil is determined by rating engine parts for deposits and wear against a reference oil.

Using the broad range of data gathered in the road testing program the Company is able to accurately correlate piston varnish deposits obtained in the laboratory test with oil ring deposits to be expected with extended over-the-road use of a test oil. Oil ring deposits in field engines are a prime factor in oil consumption which, in turn, determines useful engine life.

As a result of its proven accuracy in forecasting field performance of lube oil additives and oil formulations, it's expected that the new laboratory method will greatly minimize the need for future field testing.

(Source: Oronite Chemical Company)

AID FOR INVENTORS

Prompted by the lack of common meeting ground where inventors and industrial leaders can get together, the 80-year old Cleveland Engineering Society is sponsoring the National Inventions Conference and Exhibition from June 20-24 as a mutual service and to stimulate invention.

In addition to an exhibit of operating and non-operating units or models which are available for leasing, licensing or sale, a full program of informational talks on invention, patents, research and development, and other subjects will be given.

In judging entries the conference group will use as their yardstick for a "practical product or process" that it (1) definitely should fill a specific human need, whether it is to be used directly by the consumer or in the production of products or services; (2) should be clearly better than other comparable products or processes and not merely an alternative; (3) should have its research development completed so that it is ready, or almost ready to be put into production; (4) should preferably be one which can be readily sold through existing sales or merchandise channels; and (5) the potential market should be large enough in size and the difference between the cost and the sales price should be great enough so that substantial profits may be expected to compensate for the investments of effort, time, and money necessary to put the invention on the market and defend it against competition.

The conference group will also be interested in knowing if the item is available as a full scale unit or as a model and whether it is operating or non-operating.

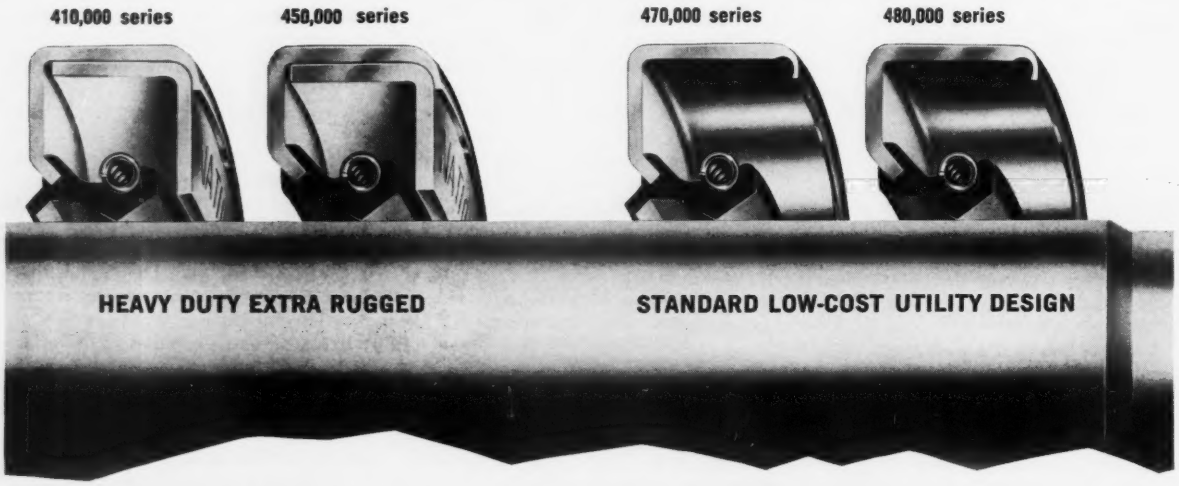
(Con't on page 135)

NATIONAL OIL SEAL LOGBOOK

Presenting...

A rugged, dependable new shaft seal for a broad variety of applications

NATIONAL BUD* SEALS



New designs proven in 4 years of field application

Permanent bonded sealing lip, longer life, leakproof sealing

Rugged case won't distort under severe press fit

Phosphate coating avoids rust

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Sealing materials for temperatures —65° F to 400° F

Operates in most oils or industrial fluids

National Seal engineers — who brought you Syntech® and Micro-Torc* —now offer a ruggedly simple new advance in precision shaft sealing —National BUD (Bonded Universal Design) Oil Seals.

BUD seals are designed for a broad variety of applications, including many where more complex single-lip and double-lip designs were previously specified.

Full details and application engineering help on National BUD or other oil seals are available from your National Seal Division, Field Engineers. See the Yellow Pages under "Oil Seals" or write direct to Redwood City, Calif., home offices.

*TRADEMARK NATIONAL SEAL

NATIONAL SEAL

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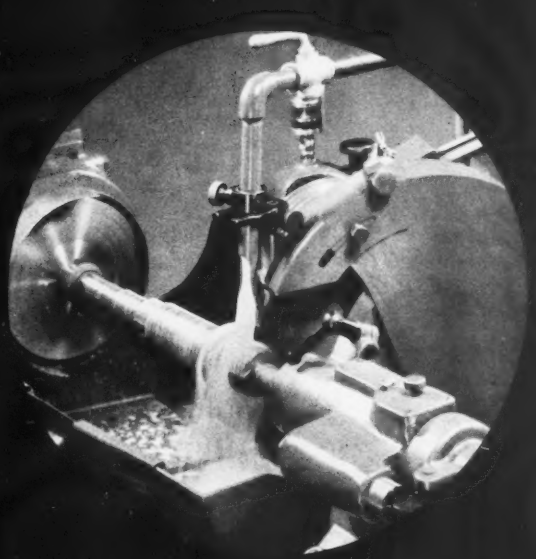
6071

This is

Stuart's

new
HI-D
at work

This is what HI-D is . . .



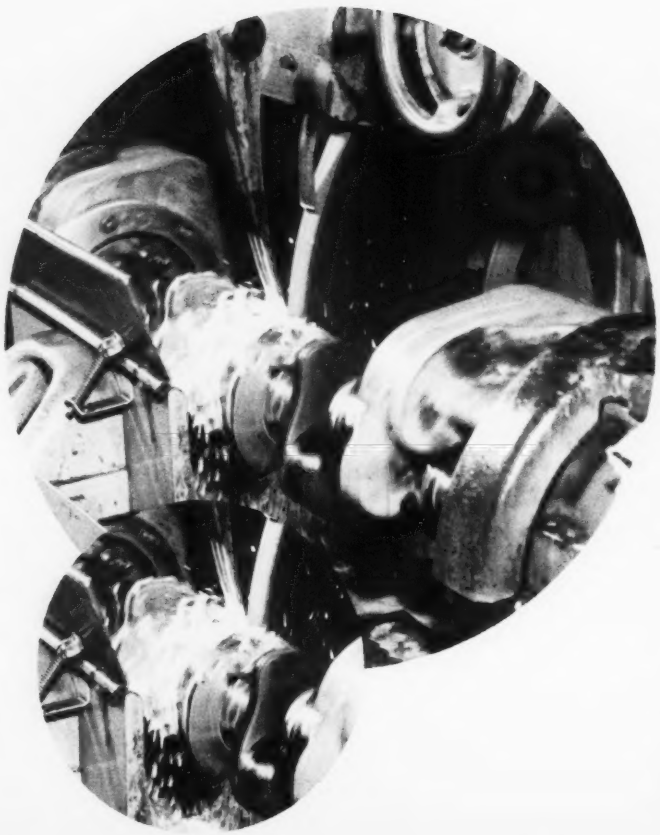
A new *transparent* metalworking compound a *petrochemical* compound possessing the high detergency of synthetics but none of their disadvantages. Often described as a hybrid—Hi-D is not truly an emulsion, and not anything like a straight chemical compound. Turn the page to see how this new type of cutting fluid can help you.

This is what

Stuart's

new **HI-D** will do...

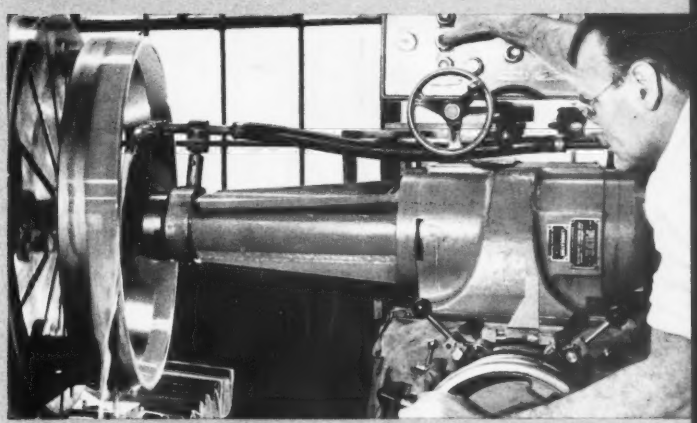
Keep grinding wheels open and free-cutting. Permit standardization of wheels—do more different jobs with fewer wheels. Minimize machine tool maintenance. Aid chip formation to produce fine surface finishes. Lubricate efficiently as it cleans. Remain effective and stable at 60:1 for grinding and at 40:1 for cutting—even after picking up tramp oil. Settle chips quickly in an ordinary sump—produce controlled foam in a flotation-type filtering system. Inhibit rust, even at mixtures greater than 60:1.



This is how

Stuart's

new **HI-D** has helped others...



LaSalle Steel Company reduced cutting fluid costs by 45%, using Hi-D for everything from ¼" roughing cuts on lathes to fine finish grinding. At 50:1, Hi-D stops in-plant rust on highly finished steel bar stock.

The Torrington Company, Bantam Bearing Division, saves ⅓ on lubricant costs by using Hi-D at 60:1 on 87 grinders. Hi-D trims *hidden costs,* too, because Torrington dresses wheels only ⅓ as often as before. Think of the savings in wheel and diamond life. Direct costs are slashed on some jobs because both rough- and finish-grinding are done with the same wheel. As for finish, Hi-D eliminates 95% of chip "feedback" from the filtering system.

Stuart's **HI-D** replaces five cutting fluids in diversified plant

Here's how Hi-D's combination of detergency and lubricity slashes lubrication costs for one company on 20 different jobs that range from sawing to surface grinding:

1. **Sawing**—Elimination of chip welding improves blade life. Ability to perform at 10:1 (5:1 formerly required) reduces carry-off and waste.
2. **Turning**—Production is increased by stepping up feed from .030 to .060 ipm. Depth of cut is increased from ⅛" to ¼".
3. **Mills**—Rancidity is eliminated.
4. **Surface grinding**—Wheel life is increased, downtime is decreased, because petrochemical compound Hi-D keeps wheels open and free-cutting.

On every application, Hi-D matches or betters the performance of five compounds replaced. Cutting fluid inventory and handling costs are reduced. Using Hi-D in the toolroom and cutoff department (serviced by a central system) saves 50 to 60 gallons of cutting fluid per week.

The way to evaluate potential savings in *your* plant is to test Stuart's new Hi-D on a variety of operations. Or, send for free test samples of Hi-D in both concentrate and mixture form that will demonstrate its transparency, lubricity, and stability. Phone your Stuart representative or the factory—BIshop 7-7100.

FREE SAMPLE

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CANADIAN D. A. STUART OIL CO., LTD.
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LUBE IN THE NEWS

(Continued)

The exhibition at the Cleveland Engineering and Scientific Center, 3100 Chester Avenue, will be open to everyone without charge, but a registration fee will be charged for those desiring to attend the conference sessions, luncheons, and dinners. Conference registration forms and program of speakers and subjects are available by writing the Society.

In addition to the exhibit of selected inventions, ideas, and processes, there will be a program covering such interesting phases as "Technique of Invention," "The Need for Inventions," "Fitting an Idea into Marketing," "The Future of Invention in Industry," and "The Manufacturer Looks to Invention."

The conference will be headed by Joseph H. Gepfert, Reliance Electric and Engineering Company.

(Source: Cleveland Engineering Society)

R. W. BELFIT ELECTED FIRST ASLE LIFE MEMBER

The first life member of ASLE was recently elected by the board of directors. He is Robert W. Belfit who retired in December, 1959 from the Scovill Manufacturing Co., after 40 years as research organic chemist.

As an ASLE member of more than ten years standing, Mr. Belfit, on his recent retirement became eligible for a life membership under the provisions of the new Constitution. He is also a member of the American Chemical Society, a fellow of the American Institute of Chemists and a registered Professional Chemical Engineer in the state of Connecticut.

Although he has formally retired from the Scovill Manufacturing Company, he will continue to be available to them as a consultant for the Closure Division on lubrication and finishes.

In addition to many other contributions to the Society, Mr. Belfit has collaborated with N. E. Shirk of the Scovill Mfg. Co., in a paper to be presented at this years ASLE Annual Meeting on the subject of "Brass Rolling Emulsions."

INDUSTRY NOTES

Low salaries at home have been blamed for the loss of British engineers to Canada and the United States.

The British Engineers' Guild, representing all fields of engineering, has predicted a steady deterioration in the efficiency of British industry unless earnings are made competitive with those in America.

A recent survey by the British government's Central Office of Information indicated a median salary of only $3,660 for mechanical, civil and electrical engineers during the 1955-56 fiscal year. Thirty per cent took home less than $2,800 and only one in four received more than $4,480. In contrast, the Guild stated that 50 per cent of U. S. engineers of age 25 received at least $6,300 during the same period, and for those aged 30 the U. S. median was $7,700.

L. Sonneborn Sons, Inc., 57-year-old New York petroleum refiner and manufacturer of chemical specialties, will change its name tomorrow to Sonneborn Chemical and Refining Corporation.

In conjunction with the proposed name change, a new company-developed symbol will be incorporated into all printed sales and corporate material of the company.

The Timken Roller Bearing Company's manufacturing operations in Canada, located at St. Thomas, Ontario have been renamed, "Canadian Timken, Division of The Timken Roller Bearing Company." This change is consistent with the Timken Company's international operations policy of identifying the manufacturing divisions of the company with the country in which it operates.

The Canadian manufacturing division of The Timken Roller Bearing Company was established to serve the Canadian bearing market in 1945. The plant has been considerably expanded since that time with the addition of machinery, personnel and buildings. Rock bits are also manufactured there for the Canadian construction and mining industries. T. W. Clift is General Manager of the Canadian division of The Timken Roller Bearing Company.

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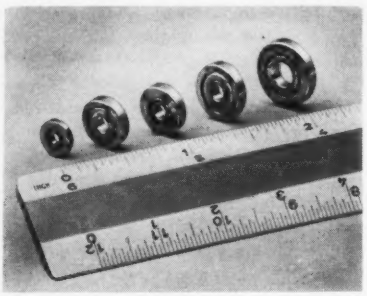
NEW PRODUCTS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

THIN-WIDTH INSTRUMENT BEARINGS AVAILABLE

A new series of thin-width precision instrument bearings designed for use in synchros, gear trains, potentiometers, servos and small motors is now available from Miniature Precision Bearings, Inc.

Featuring a high outside diameter/width ratio, the new MPB bearings were developed originally for use in synchros where precision and reliability are prime requisites. Found to be ideally suited for other applications, nine thin-width bearings were incorporated into the new standard series which is available without premium charge. The relatively large O. D. reportedly enables designers to use economical through-bored and through-ground housings, resulting in more efficient production and improved bearing alignment. The narrow width of the new bearings is said to save space, making possible the use of longer stators and rotors in synchros and small motors, increasing power without adding to the overall length or diameter of the unit.



Made to ABEC class 7 tolerances, thin-width bearings are available from MPB factory and area office stocks in nine sizes with outside diameters from .2750" to .5000" and bores from .0937" to .1875". Standard material for balls and rings is 440C stainless steel. Open, single and double-shielded bearings are included in the series.

The new bearings are described in detail in Bulletin 6002, available on request from MPB, Inc., Precision Park, Keene, N. H.

OIL CONDITION TEST KIT ANNOUNCED

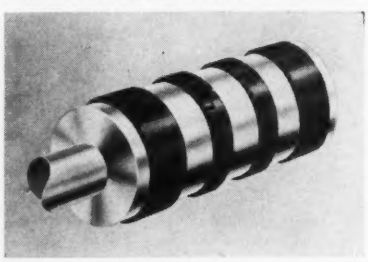
The Gerin Corporation announces a new Model PK4 crankcase Oil Test Kit, in step with the present day tendency to make lubricating oils with more and more detergency.

The manufacturer claims an exclusive feature of the Kit, which does not use blotters, is the ability to show the definite amounts of contaminants and deterioration of the oil. The tests show whether to change oil or filter or not to change and whether an engine needs attention because of fuel or water or metal particles found in the oil.

Other features are quickness of the tests and accuracy of results. The mechanic or operator can test for fuel dilution; water and anti-freeze leakage; acidity; metal particles; dirt; soot; etc. in one to twelve oils at the same time. Users of the previous Gerin Test Kit will be able to convert their kits to the new features of the PK4.

Bulletin 400 "How To Know What's Going On Inside Your Engines Before It Cost You Money" is available free from Gerin Corp., Avon, N. J.

TEFLON FILLED RINGS OFFERED



Filled Teflon piston rings are now being marketed by The Garlock Packing Company, Palmyra, New York. The new piston rings are said to be ideal for non-lubricated service to seal reciprocating, oscillating and rotary motion of both external and internal cylindrical

NEW PRODUCTS
(Continued)

surfaces against the leakage of liquids or gases. Matched filled Teflon rider rings are also available for use in conjunction with the rings where long stroke or heavy pistons necessitate additional support.

The piston rings are made from specially processed carbon-filled Teflon. They reportedly have exceptional thermal stability and are suitable for continuous service in a temperature range from −420° to 500° F. These rings are tough, abrasion-resistant and are said to have the ability to imbed hard foreign particles without adversely affecting the cylinder life or the ring itself.

The rings are available in many different designs including butt joint, step joint, scarf cut or solid design. The company also offers glass filled Teflon.

Further information about piston rings and rider rings may be obtained by writing to The Garlock Packing Company, 444 Main Street, Palmyra, New York.

NEW MAINTENANCE CLEANER MARKETED

A fundamentally new chemical concept has led to the development of a new maintenance cleaner by S. C. Johnson & Son, Inc., Racine, Wis., the company has announced. The cleaner is said to solve the toughest cleaning problems, yet is safe for all washable surfaces such as floors, ceilings, walls and machinery.

Developed by the makers of Johnson's Wax, the new product called "Forward" has an exceptionally high alkaline cleaning power but is silicated-buffered for safety, the company said.

The formula fights off the neutralizing action of dirt, it is said, and as a result, when a mop or sponge transfers dirt to the cleaning solution, there is no fade-out of cleaning power.

Because of its effectiveness against oil and grease stains, Forward is especially recommended by the maker for cleaning pumping equipment, floors, walls, rolling stock, equipment, and other problem areas.

The cleaner is available nationally from maintenance supply houses in 5-, 30- and 55-gallon containers. The recommended dilution for general cleaning is 1 to 32 and for extra-heavy cleaning 1 to 15.

THREE-STAGE FULL-FLOW FILTER

Purolator Products, Inc. announces production of a new three-stage filter, consisting of a specially developed highly-controlled, non-woven material sandwiched for support between a coarse wire screen and a cellulose sheet.

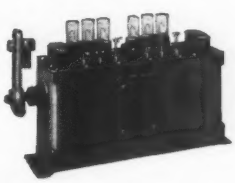
The new three-stage element consists

(Con't. on page 139)

HOW TO educate

a drop of oil!

Just put it through a Manzel force-feed lubricator and any oil drop knows where it's going and how to get there fast. Manzel lubricators deliver just the right amount of oil to bearings, cylinders and packings. They start, stop, speed up and slow down in perfect synchronization with your machinery...unaffected by high steam, gas or air pressure. Whatever your field, there's a Manzel lubricator to meet your needs. For our catalog, write Manzel, 254 Babcock Street, Buffalo 10, New York. Whatever your lubricating problem, you get the right answer if you



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702's unique combination of properties has wide application—is now used commercially in automotive, aviation, diesel and outboard engine oils; also in automatic transmission fluids and a wide range of industrial lubricants.

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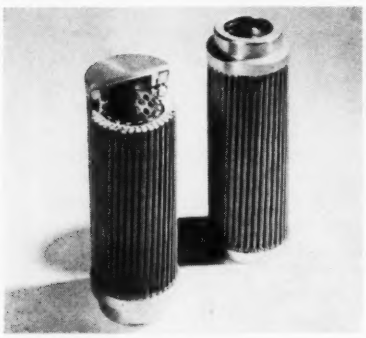
NEW PRODUCTS

(*Con't. from page 137*)

of an outer medium—a coarse wire screen (200 × 200)—which filters out the large particles. The primary function of the outer wire screen is to provide support for the non-woven center media. The inner medium, a resin-impregnated cellulose sheet, is designed as an additional support to prevent migration of the primary filtering medium. The inner medium also serves as a filter and barrier providing final "polish" and separation of contaminants.



Reportedly capable of 1 micron filtration, the new three-stage element has been rated at submicronic filtration in tests on hydraulic and pneumatic systems. In tests, the new elements—available in sizes from 2 to 10 gpm—are said to have filtered 20 grams of AC fine dust at a pressure drop of only 4 psi or 60 grams of AC fine dust at a pressure drop of 60 psi (applicable to the 10 gpm element). When common hydraulic fluids are used, the three-stage filter is not affected in a temperature range from −65°F. to +275°F.

For further information about Purolator's new three-stage filter, write: Purolator Products, Inc., Rahway, N. J.

FILTER DESIGN ALLOWS EASY CLEANING

A new filter design which allows for removal and cleaning of the element while keeping pipe lines uncontaminated is now available from Micro Metallic Division of Pall Corporation, Glen Cove, N. Y. A simple clamp closure permits removal of the body tube, cleaning and reinstallation in minutes.

The new filter comes in several pipe sizes. It contains a porous metal element which can be used with or without a filter aid. Elements can be supplied as cylinders, bayonets, stars or in special types. Materials available include stainless steel (standard) or monel, nickel, inconel and others on special order.

The new filter can be designed to withstand up to 10,000 psi; 125 or 300 psig is standard. It is said to offer a larger filter surface area per unit volume than any other type of filter. Filtration is available to as low as 2 microns nominal.

NEW FILTER ANNOUNCED

Dravo Corporation, Pittsburgh, Pa., has announced it will offer a completely automatic diatomaceous earth/Fuller's earth filter recently developed by DeLaval Turbine Pacific Company, Millbrae, Calif.

It is designed to eliminate oxidation contamination and other foreign matter which the coolant picks up during rolling of steel and aluminum. Because the filter removes particles one-half micron and smaller, the clarity of the effluent is not exceeded by any other form of treatment, thus preventing stains on aluminum previously caused by partly clean—but not clear—coolant. In addition, the filter contains no cartridges.

The filter represents an addition to the line of Dravo-DeLaval lubrication and coolant systems for the steel and aluminum industries.

CYLINDRICAL ROLLER BEARINGS ADDED TO LINE

Cylindrical roller bearings that feature "Super Finish" rollers and raceways are new products announced by Hoover Ball and Bearing Company.

These new roller bearings join Hoover's line that includes ball bearings in a wide variety of types and sizes together with spherical roller bearings.

According to Hoover, raceways and rollers are "Super Finished" to obtain exceptionally smooth, mirror-like working surfaces for increased life and performance.

The new Hoover cylindrical roller bearings are designed with crowned rollers that provide exceptional radial load capacity for a conventional-size, standard-width, single-row bearing. Because they are cool-running, high-speed operation under heavy radial loads is said to be possible. Retainers are machined solid bronze.

Hoover cylindrical roller bearings are offered in three widely used series in a complete range of sizes. Each series provides the option of five variations—straight inner race, straight outer race, single flanged inner race, single flanged outer race, and single flanged inner race with stabilizing ring.

Dimension, load and other application information is contained in Hoover's new twelve-page Bulletin No. 114. Copies may be obtained by writing Advertising Department, Bearing Divison, Hoover Ball and Bearing Company, 5400 South State Road, Ann Arbor, Michigan.

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PRODUCT LITERATURE

BULLETIN ON ALL-PURPOSE GREASE AVAILABLE

A bulletin on AMALIE-brand All-Purpose Grease is available from L. Sonneborn Sons, Inc., refiners and marketers of Amalie Motor Oils.

The bulletin covers the various uses to which the grease may be put, including application to chassis, wheel bearings, water pumps and universal joints.

The bulletin also contains complete data on the grease and its primary uses.

Copies of the bulletin (Current Topics No. 14) may be obtained by writing L. Sonneborn Sons, Inc., 300 Park Avenue South, New York 10, New York.

FOLDER DESCRIBES PRESSURE-LOCK FILTER ELEMENTS

Pressure Lock Filter Element Folder from Purolator Products, Inc., describes a new type of hydraulic and pneumatic filter element free of "built-in" contaminants and lighter in weight.

The folder details information on the pressure-locking process in which end caps, center tube, and filter medium are mechanically locked under high pressure, locking the filter element in the parent metal of the end caps to form a leak-proof seal, this is said to eliminate the contamination resulting from oxidation products and flux normally encountered in conventional joining processes and making it possible to fully utilize the inherent operational characteristics of filter construction materials.

Specifications for five types of elements covering rated flow capacities of 0.5, 3, 6, 12, and 24 gallons per minute plus details on degree of filtration, temperature range, construction materials, fluids, and minimum collapse pressure are included in the new folder.

For copies of the new Pressure Lock Filter Element folder, write: Department 132, Purolator Products, Inc., Rahway, New Jersey.

REVISED BROCHURE ON CENTRALIZED LUBE SYSTEMS

A newly revised general brochure now contains information on the complete line of centralized systems of lubrication offered by Farval Division, Eaton Manufacturing Company.

The booklet has been increased to 24 pages to cover new additions to the Farval line. Advantages of Farval Centralized Lubrication and principles of operation are discussed, as well as system components. Illustrations of typical applications are also included.

The new Bulletin No. 26-T is available upon request to Farval Division, Eaton Manufacturing Company, 3300 East 80th Street, Cleveland 4, Ohio.

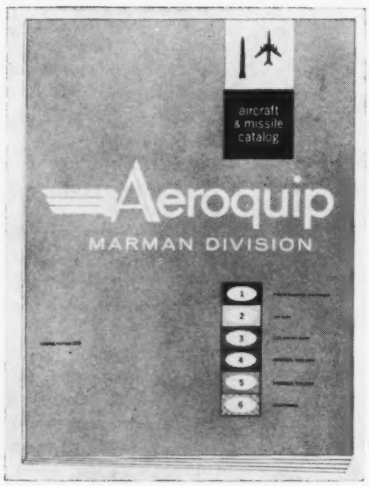
BROCHURE EXPLAINS DRY FILM LUBE

Poly Chem, Inc., manufacturers of a new bonded dry film lubricant, announced today the availability of a 4-page, 2-color brochure explaining the basic principles of POXYLUBE.

POXYLUBE is the new moly base dry film lubricant that is applicable for commercial production use since the manufacturer reports there is no surface pre-treatment necessary prior to applying the lubricant.

To receive this brochure and further technical information, write to: Poly Chem, Inc., 541 So. Webster Ave., Indianapolis 19, Indiana.

TUBING AND DUCT JOINT CATALOG AVAILABLE



A design information catalog for aircraft and missile tubing and duct joints is now available. All products shown in the catalog are available from stock in a wide range of sizes for immediate delivery. This 40-page catalog contains helpful design data and product information on joints suitable for a wide range of temperatures and pressures for gaseous, liquid and air systems, as well as couplings for fastening and sealing applications.

Copies of this catalog may be obtained by writing the Advertising Department, Aeroquip Corporation, Marman Division, 11214 Exposition Boulevard, Los Angeles 64, California.

PERSONALS

R. M. Waples, chairman of the board of Garlock Packing Co., announced his retirement from active service effective immediately after the annual meeting of the company's stockholders, April 6, 1960. He will remain a member of the board of directors.

James Marmor has been appointed contract co-ordinator of the Military Products Department of Garlock Packing Co. He was formerly with the Missles and Space Division of Lockheed Aviation, where he was technical co-ordinator for the Polaris program.

The E. F. Houghton Co., announces two appointments to its headquarters staff in Philadelphia; W. J. Walton has been employed as lubrication engineer, and N. F. Monahan has been named assistant to the manager of the Hydraulics and Transmission Department.

Climax Molybdenum Company, a Division of American Metal Climax, Inc., has named C. Eric Ho as manager of Catalyst Sales and Development. Mr. Ho has been with the company since 1958, serving until now as assistant director of Marketing Research.

C. Eric Ho

H. J. Lang

Fiske Bros. Refining Co. announces the retirement of **David A. Butler** after 39 years of service, and the appointment of A. E. Van Schoick as service engineer handling industrial lubricants and metal working oils.

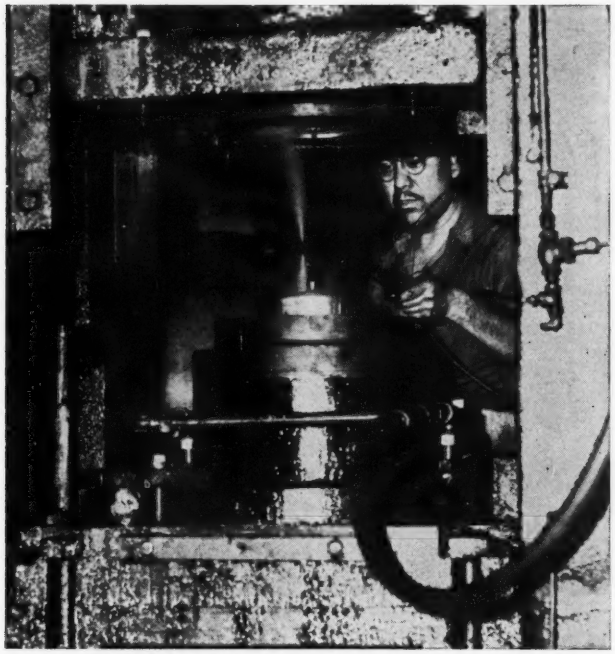
Appointment of **Henry J. Lang** as sales representative for the state of Michigan has been made by the Acheson Colloids Co. For the past three years, Mr. Lang has been employed in the Philadelphia office of the company serving the Atlantic seaboard area.

Newly elected directors of the L. R. Kerns Co., and the Kerns Pacific Corp. held their first meeting on January 14. They are, from the L. R. Kerns Co.: D. E. Fredericks, vice president; J. H. Maris, St. Louis district sales manager; M. H. Schellenburg, secretary-treasurer; **B. L. Smalley,** president and chairman of the board; S. F. Gordon, executive vice president; B. W. Glenn, vice president-sales; F. A. Zellman, chief chemist, and from the Kerns Pacific Corp., N. E. Ornstein, plant superintendent; A. L. Spalding, president.

(Con't. on page 143)

FORGING OR TAPPING . . . 'dag' DISPERSIONS BRING IMPRESSIVE SAVINGS

The versatility of Acheson 'dag' brand dispersions has been proven in many metalworking applications. Here are two such examples: the one involving the material-time savings possible by the use of sprayable colloidal graphite; the other, overcoming pressure and frictional heat problems with the use of a mica dispersion by Acheson.



'Prodag' is automatically spray-applied simultaneously on both upper and lower die surfaces of this forging press at Mueller Brass.

Mueller Brass Company saves $15,000 a year in labor-material costs alone. This is in addition to increasing die life, reducing the scrap loss, and improving the finish of their forgings . . . the reasons why Mueller initially chose Acheson's Prodag® over other forging lubricants. The total savings can be estimated as "considerable", since this Port Huron, Michigan company is the world's largest producer of brass and bronze forgings.

Before using 'Prodag' — a dispersion of graphite and water, Mueller lubricated their crank forging presses with a highly viscous, petroleum-based material which had to be swabbed by hand between each press stroke. The human element frequently meant too much lubricant being applied in some areas of the die, too little in others. The result in the first case, was either imperfect forgings or cracked dies brought about through displacement pressures. In die areas where there was insufficient lubrication, metal stuck in the die cavity. The forged piece had to be scrapped and time was lost while the metal was pried out of the die.

To overcome these multiple problems, Mueller was introduced to a sprayable lubricant and designed their own spray equipment, which lubricates lower and upper dies simultaneously. In this application, 'Prodag' is diluted 1 to 35 with water and is kept under agitation at the press. Time studies have shown that spraying has given them a five percent-per-pound economy over swabbing. Even more importantly, the use of 'Prodag' has resulted in more uniform, complete coverage. The $15,000 to $17,000 annual labor-material savings has, in Mueller's opinion, actually been a "bonus" over and above their original purpose of achieving better forgings and greater die life.

'dag' 242 improves hole tapping operation at General Steel Wares' Montreal Plant

Hole-tapping operations at General Steel Wares, Ltd., Montreal, Quebec, have improved with the application of 'dag' 242 — a dispersion of mica in petroleum oil. So much so, in fact, that an annual savings of approximately $8400 has been realized. The problem was this: broken spud threads during tapping operations on galvanized range boilers, caused a reject percentage of 27%. Fed to the tap as pictured below, the area of the boiler spud was subjected to high pressure and frictional heat. A proprietary type of water-soluble paste had previously been used.

Mr. E. R. Hails, Works Manager at General Steel Wares, found, after detailed investigation of all components involved in the operation, that the lubricant was the key to greater efficiency and fewer rejects. 'dag' 242 was recommended and put into use. Applied by brush to the tap and spuds, this material was immediately effective. The results speak for themselves; from an average life of 3000 spuds per tap, General Steel Wares now averages over 14,000 per tap with 'dag' 242.

Before threading range boiler holes, 'dag' 242 is applied by brush to the tap and spuds.

Perhaps you could be earning similar production economies by using one of the many fine Acheson Dispersions tailored for metalworking use. For further information write for your copy of Bulletin 426 — For Metalworking Applications. Address Dept. LE-40

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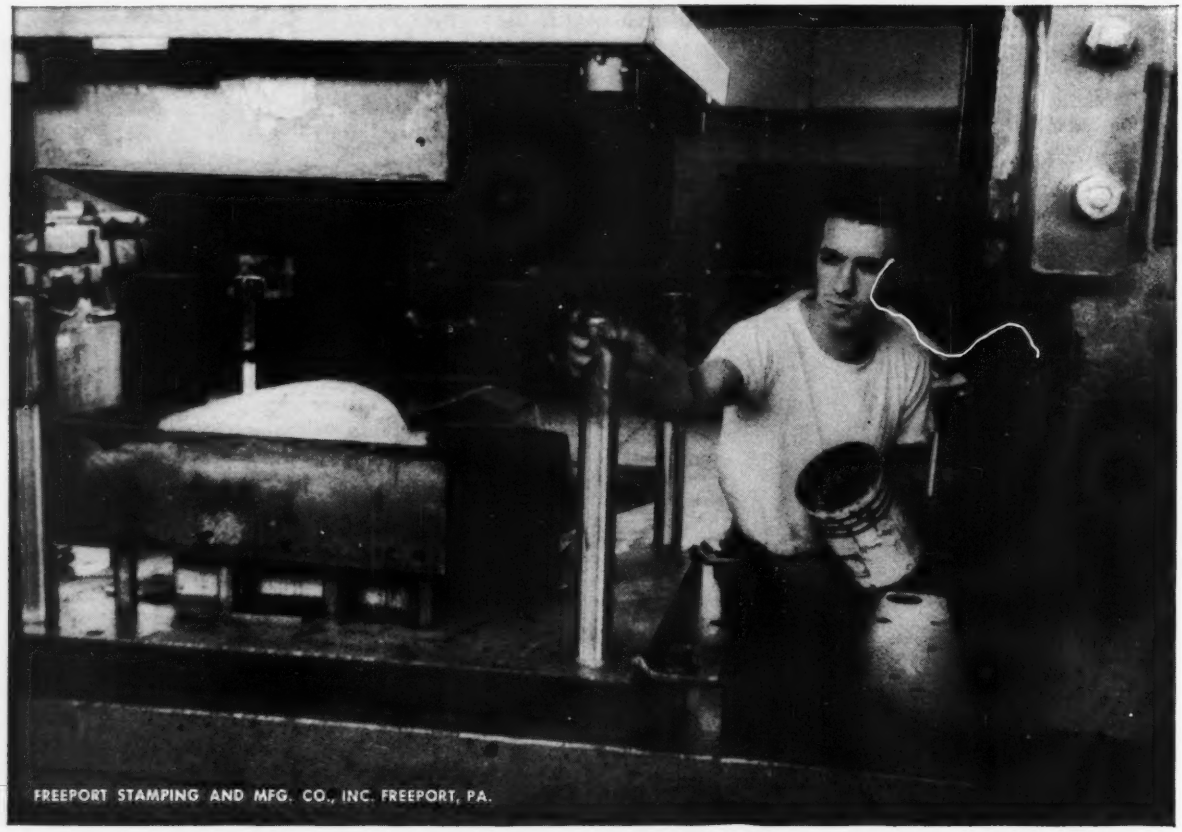


FREEPORT STAMPING AND MFG. CO., INC. FREEPORT, PA.

"Die Guides Needed Grease Every Few Hours... Cities Service Trojan HM Stays for Days"

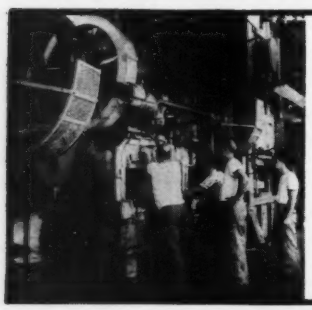
Freeport Stamping has built a reputation for ultra-precision in its stampings. But one annoyance kept bothering the production department . . . die guides had to be lubricated every few hours or they started to bind and gall. Cities Service Lubrication Engineer, Robert Vey, suggested a change to new Trojan HM Grease, containing 3% molybdenum disulfide.

The very first application of Trojan HM kept the die guides operating smoothly for three days instead of the usual three hours. Cities Service Trojan HM Grease is a new lithium base lubricant combining high temperature characteristics with excellent low temperature pumpability, good water-resistant properties and high stability. New Trojan HM Grease is a tenacious lubricant with a plating action that extends the period between servicing.

If you have a grease problem, Cities Service is eager to serve you with free technical assistance and a full line of special and multi-purpose greases. For full information call your nearest Cities Service office or write: Cities Service Oil Company, Sixty Wall Tower, N. Y. 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS



All Eleven presses at Freeport Stamping operate with Pacemaker #3 hydraulic oil. Pacemaker is a multi-use quality lubricant that helps reduce inventory. Freeport also uses Pacemaker in machine tools, and electric motors.

Compound Curves with one draw are possible with Cities Service Drawing Compound. Automobile parts being made for two major manufacturers, are used in a visible spot so they must be free of die marks as well as precision drawn.

PERSONALS

(*Con't. from page 140*)

A. J. Kelly, Esso Standard's general manager of purchasing, retired on March first, ending a 41 year career in Esso purchasing operations. Mr. Kelly was named general purchasing agent for Esso Standard in 1948 and general manager of the purchasing department in 1954.

Appointment of T. F. O'Rorke as district manager of distributor sales for Michigan outside of metropolitan Detroit has been announced by the Parker-Hannifin Corp.

Donald F. Wilcock has been transferred to the Ordnance Department of the General Electric Co., Pittsfield, Mass., as consulting engineer—Laboratory.

Recent additions to the staff of the Development and Service Department of Emery Industries, Inc., include J. J. Siewert, F. C. Stroehlien, J. Boylan, and P. M. Clark. Their appointments are part of a general expansion to meet the increasing demands for the department's services.

R. E. Griswold has been appointed assistant to the Dallas Division manager in the Domestic Producing Department of Texaco Inc. Mr. Griswold has been staff geologist in the New York offices since 1958. His new appointment became effective March first.

R MIX PRODUCTS

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SECTION NEWS

CINCINNATI ..... "The United States has the edge on Russia in space science," Dr. Hugh L. Dryden, Deputy Director of the National Aeronautics and Space Administration said in Cincinnati. Dr. Dryden was addressing the Silver Anniversary Meeting of the Technical and Scientific Societies Council of Cincinnati, of which the ASLE Cincinnati Section is a participating society. In an interview, Dr. Dryden indicated that although the Soviets enjoy massive superiority in the weight-carrying capacity of space rockets, the overall picture of space exploration gives the edge to the United States. This country is about 1½ years behind Russia in the weight-carrying ability of space rockets, but this has hurt most in the area of guidance, the NASA deputy said. The guidance systems in our space rockets so far "have been rather primitive things," related Dr. Dryden. The 25th Annual Meeting of the Technical and Scientific Societies Council of Cincinnati was sponsored by 24 participating societies. Most national and local offices of the various societies were in attendance with Dr. A. B. Wilder, president; C. L. Willey, executive secretary and Frank Rosen, Cincinnati Section chairman, representing ASLE. ..... LOS ANGELES ..... The regular March meeting was held at the Carolina Pines Restaurant with S. R. Calish, Jr., California Research Corporation, as speaker. Mr. Calish's talk "Trends in Automatic Transmission Fluids" covered a brief historical background of automatic transmissions and their lubricants. He described the various classes of transmissions together with their performance requirements. Laboratory tests were outlined and various manufacturers' viewpoints given. ..... MONTREAL ..... Attendees at the March 2 meeting heard a talk on "Sleeve Bearing Materials" given by E. R. Booser, of the General Electric Company, Schenectady, New York. Mr. Booser served as National President of ASLE in 1957-58. He has written 18 papers on bearings and their lubrication, and recently co-authored a book on Bearing Design and Application. ..... NEW YORK ..... A. B. Wilder, ASLE president, was guest speaker at the March meeting. Dr. Wilder is associated with the E. I. duPont de Nemours Company in Chicago. He gave a thumbnail sketch of the national organization and activities of ASLE before his scheduled talk on "Trends in Lubrication Requirements." The subject covered the limited application of some lubricants and the work being done to extend the boundaries of lubrication in specialized fields. The meeting was also designated as Past Chairman's Night. ..... PHILADELPHIA ..... As a non-profit service to firms and individuals interested in the various phases of the metals industry, the Philadelphia Section offered a one day symposium on "Metal Working, Fluids, Lubricants, and Tools." The Symposium was held on Wednesday, March 30, at the Esso Building. The sessions covered were: Metal Working Additives, by Robert Smith, E. F. Houghton Co.; Chemical Coatings for Cold Forming Operations, by Hugh Gehman, Anchem Products Co.; Metal Working Lubricants, a film by Texaco; Lubrication Practices in Metal Drawing and Extrusion Processes, by Salvatore Coscia, Kelsey-Hayes Co.; Fluids for Grinding Metals, by John Murray, Esso Standard Corp.; Metal Working Lubrication, by James Johnson of Atlantic Refining Co. The organizing committee, headed by H. H. Klug of the Scott Paper Company, consisted of T. J. Bowes (Cities Service); J. H. Gaul (Lincoln Engineering); E. J. O'Donnell (Alemite); Marco Petronio (Frankford Arsenal); E. W. Walter (Sun Oil); and S. Wedemeyer (Esso). All those who attended were given a collection of booklets and pamphlets related to the subject. ..... SYRACUSE ..... Instead of the regular March meeting date, the Syracuse Section met in conjunction with the local section of the Society of Automotive Engineers on Tuesday, March 8, at the Corinthian Club. L. E. Burgess, Chief Engineer of Mack Trucks Inc., was speaker at the meeting. His presentation covered the subject of "Off-Highway Equipment" and included pictures of equipment used in this country as well as that used in other countries.

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is the word to describe

"A Survey of Journal Bearing Literature"

by Professor Dudley D. Fuller, Columbia University. A research project financed by the American Society of Lubrication Engineers with the cooperation of industrial sponsors.

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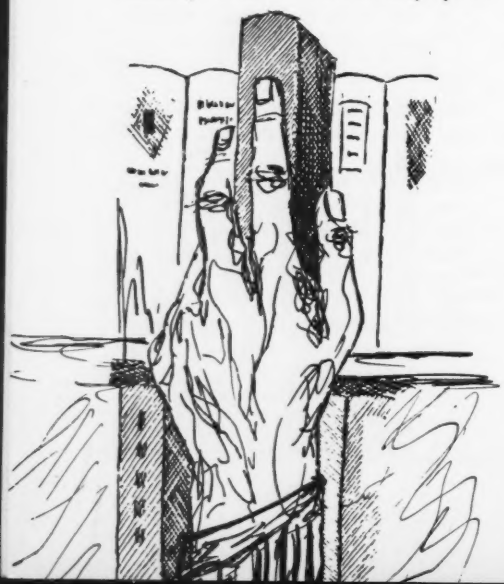

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Lube Lines

by A. F. Brewer*

ALIGNMENT AND LUBRICATION

There is a definite relationship between shaft alignment and lubrication. When there is misalignment the probability of aggravated friction exists which can promote abnormal or uneven loading of bearings to result in wear and increased clearance.

Flexible couplings are used to compensate for misalignment. In reality they are insurance factors, installed between the shafting of driving and driven machinery.

THE CAUSE

Some misalignment can prevail from the very beginning; usually it is virtually impossible to obtain perfect alignment between connecting shafts.

Then again, and this is more probable, misalignment may develop in service due to vibration or settling of foundations. In locations where earth tremors might occur, or on filled or made land, this matter of settling could require periodic checking in order to shim up the connected units, or to adjust the couplings.

RESPONSIBILITY GOES BACK TO DESIGN

Fundamentally alignment must be considered during every stage of the design period. Virtually every machine today involves a considerable number of moving parts which must function in perfect unison with each other. Usually they comprise precision elements such as gear trains, bearings designed with carefully calculated clearances, cams, eccentrics or chain drives. In effect they all involve power transmission to some functional part of the machine, which is related to production.

The designing engineer fully realizes his responsibility for the ultimate performance of the machine. Fortunately he is favored by the fact that the assemblies of mechanisms he is planning are to be contained or located in relatively fixed supports which do not lend themselves readily to misalignment provided the machine-work and installation procedures have followed the designers specifications.

During the design period the importance of lubrication also must be considered. Here the manner of housing is a factor.—Can it be sealed so effectually as to permit of fully centralized pressure or bath lubrication with relatively low viscosity oils, for example, as in the automotive engine? Or, would centralized grease lubrication or automatic metered oil delivery be best, as on so many production units today? Unless the lubricating system gives perfect protection gear tooth surfaces could be subject to welding or surface deterioration as a result of pressure and temperature increase; or, bearing clearances or rolling could be affected. These conditions could throw the assembly sufficiently out of line so that the production accuracy of the finished work would be adversely affected, or the wear conditions could become progressively worse until a major repair job might be required.

SO WE COME TO INSTALLATION

Given a machine which has been properly designed, machined and assembled, the installation engineer then takes over the responsibility of seeing that it is properly located with respect to its function in the production line. He must know topography and land conditions as well as mechanics for he must plan the foundations of both driving and driven elements as well as the coupling supports. It is all very well to pour a concrete foundation to a stipulated depth and with the usual reinforcement, but if one end is located over rock and the other over back-fill or sand which could be subject to shifting, settling later could cause a serious case of misalignment.

This is why designs are so carefully checked and land areas are surveyed and soundings made. The most perfect installation is one where the foundation is laid on bedrock, but too often this is impracticable.

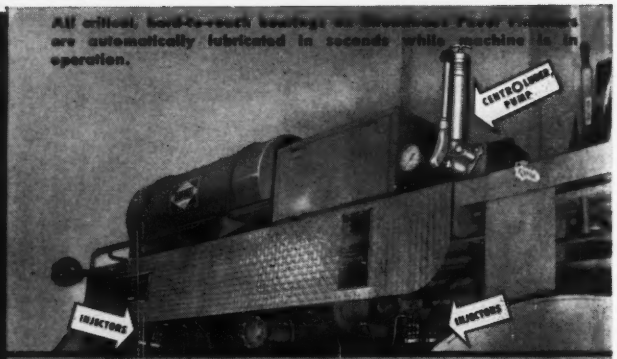
INSURANCE VALUE OF THE FLEXIBLE COUPLING

We've already mentioned that the flexible coupling compensates for misalignment. Basically the flexible coupling is a type of power-transmitting device the components of which may be subject to varying loads according to how much misalignment prevails or the extent to which it may change. Accordingly the flexible coupling must be designed as carefully, and machined as precisely as the driving and driven units which it connects. Unless this is done heat can be generated within the coupling to promote wear. The designer of the lubricated flexible coupling anticipates this possibility by using suitable floating members, gears, or flexible chains, etc., which are housed so as to contain lubricant and to enable it to circulate between the contact parts. Obviously however, the amount of heat to be expected (aside from the heat from outside sources) will depend upon the amount of relative motion.

Since it is the frictional heat which is most damaging, managerial respect for design and lubrication is mandatory. It is possible to pinch pennies here as well as elsewhere, but it doesn't pay in the long run. Correction of misalignment can be one of the most costly items in plant machinery maintenance. Don't let the "want of a nail" throw the "horsepower of production" out of kilter.

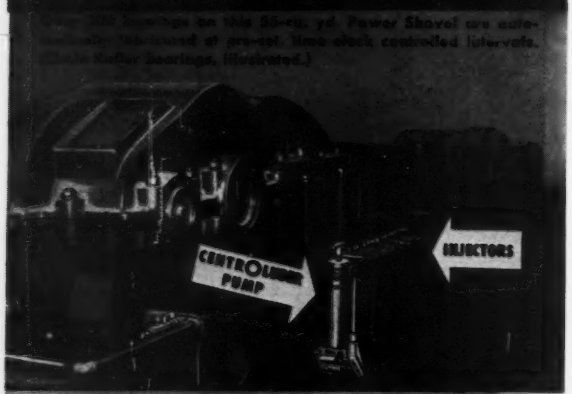
* Consultant and author "Basic Lubrication Practice."

LINCOLN POWER LUBRICATION SYSTEMS

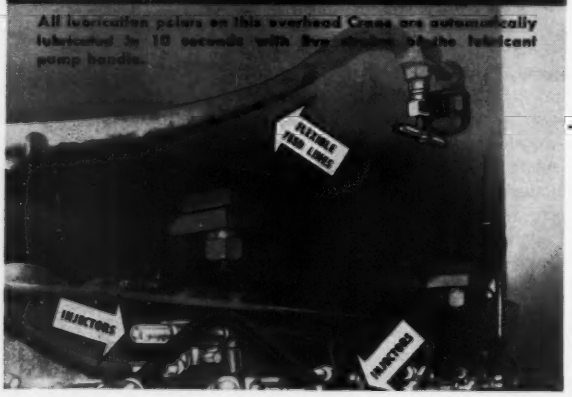


All critical, hard-to-reach bearings on [illegible] Power Excavators are automatically lubricated in seconds while machine is in operation.

Hydraulic centralized lubrication system lubricates 68 bearings automatically on Coal Loaders. System cycles at pre-arranged number of movements of the loading head.



[illegible] bearings on this 55-cu. yd. Power Shovel are automatically lubricated at pre-set, time clock controlled intervals. (Crawler Roller Bearings, Illustrated.)



All lubrication points on this overhead Crane are automatically lubricated in 10 seconds with five strokes of the lubricant pump handle.

With new equipment costs at an all-time high and depreciation allowances brutally low, you need and want longer, more productive machine life in your plant.

Progressive manufacturers of many types of heavy-duty machinery and equipment are extending service-life, eliminating downtime for lubrication and cutting operating costs by installing Lincoln Power Lubrication Systems. Lincoln automatic centralized systems are sealed from pump to bearing, delivering refinery-fresh lubricant at all points simultaneously, while machinery is operating.

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Vol. 16, No. 4

Lubrication Engineering

time for an accounting

Individuals in this great land of ours have established for themselves definite times for an accounting of their activities. The Bureau of Internal Revenue requires that we account on an annual basis for purposes of income evaluation. On a weekly basis, we account for our moral and spiritual activities.

At the time of the Annual meeting of our society the President must account to the members for his activities during the year he has been in office. Our Society has certain aims and purposes backed up by a constitution which govern the activity of all of its members. During the period an individual holds an office in our Society, he is charged with adhering to the rules and regulations governing these activities.

Each president of ASLE desires to conduct himself in a manner which will enhance the prestige of our great organization. No president does all the things he would like to do during the short term he holds office. He relinquishes his term of office with this thought in mind.

The Annual Meeting is a time when all of the members are privileged to get together and discuss problems in connection with Lubrication Engineering which are pertinent to everyone. It is at this meeting that our Section Officers are privileged to report on their activities and make recommendations for a rapid expansion of our society with reference to increasing membership, improving technical papers at the local level and providing greater information to all members of the society and industry.

The Society is backed up by eleven Technical Committees and twelve Industry Councils, all serving industry in order to provide better lubricants with reference to quality, handling and application. The Society also serves as a clearing house for the publication of material pertinent to Lubrication Engineering. We are proud of our publications.

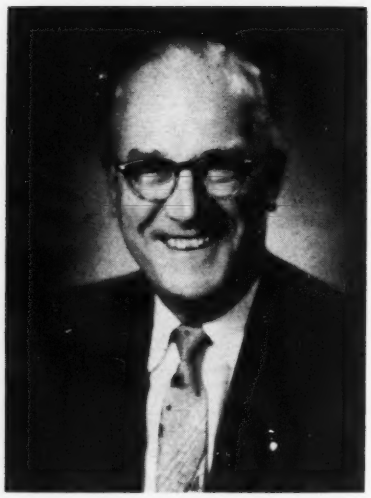
It's been our aim to upgrade the status of the Lubrication Engineer for the benefit of everyone. The Lubrication Engineer plays an important function in our society whether he is in the sales, research, or plant activities.

It is my desire to extend to everyone interested in the Science of Lubrication Engineering a most hearty welcome to our Annual Meeting.

A. B. Wilder
President, ASLE

THE LUBRICATION ENGINEER IN ACTION

Report No. 1— Dean M. Cleaveland at Bendix Products



Dean Cleaveland is a familiar and active figure in Lubrication Engineering circles. Almost continuous activity, including manufacturing and selling as well as engineering, since being graduated from Ohio State in 1921 as a chemical engineer makes him a "dean" in deed as well as in name. The last 20 years of this long career have been spent at the Bendix Products Division of Bendix Aviation Corporation. Mr. Cleaveland enjoys country living with his wife and daughter on a 30 acre piece just outside of South Bend, Indiana, home of Bendix.

Editor's Note:

The Lubrication Engineer's basic responsibility is to assure best possible performance at lowest possible cost through the application of scientific principles to lubrication. The manner in which he carries out this responsibility varies with company organization and his own individual approach. To find out how these factors contribute to a successful lubrication program, *Lubrication Engineering* has engaged the well known industrial writer, Mr. R. M. Skallerup to interview various prominent Lubrication Engineers and to describe for our readers how each of these men carries out his function in his particular company. The above article is the first of the series.

A common household detergent, unfortunately a little too strong on the alkaline side, is the villain of a story that helps bring a common lubrication engineering problem into sharp focus as it occurs at Bendix.

The story began when a production supervisor, prompted by the glowing claims of a television commercial, decided to perform an experiment. Picking up a supply of the new cleansing agent that "was sure to work like magic" from a local grocery, he charged it into his degreasing equipment in place of the recommended detergent in general plant use.

Then, hopefully as visions of Columbus, Edison and Bell danced through his head, he watched. Lo and behold, it worked! As a matter of fact, it even seemed to work a little better on the bright aluminum parts than the old detergent. Who needs an "expert"?

But the storm was gathering. And a few days later it broke as production run parts began to come back, rejected for "smutted" surfaces. Naturally, the recent change in degreasing procedure was questioned at once. But the new cleaning agent seemed to work so well. What had happened?

Then, just one day many wasted man hours too late, the production supervisor finally took the lubrication engineer into his confidence. His side of the brief conversation tells the whole story. "What? Alkali? Of course I know what smuts a fresh aluminum surface. How was I to know it was so strong? We'll switch back to the old detergent right away."

There the incident ends. But the occurrence, and a hundred others like it, emphasize the need for centralized control and uniformity in the application and specification of lubricants and related materials. Maintaining this control and uniformity at Bendix Products Division of the Bendix Aviation Corporation in South Bend is one of the most important phases of Dean M. Cleaveland's job as lubrication engineer.

The size and complexity of the operation make it quite a problem. Shops ranging from a completely air conditioned aircraft component production area to high speed automotive brake system assembly lines cover a 55.5 acre area. It takes more than 12,000 workers, nearly 2,000 of them engineers and technicians, to man the huge plant.

Lubricants, solvents, cutting oils and coolants are required in proportionately large quantities. The total handle of Cleaveland's department, including purchases of new material and reclamation of used materials, runs to well over 500,000 gallons monthly. His crew numbers 35 men and the special self-propelled tank wagons that solve the intraplant transportation problem shuttle continuously between the oil house and remote oil storage areas.

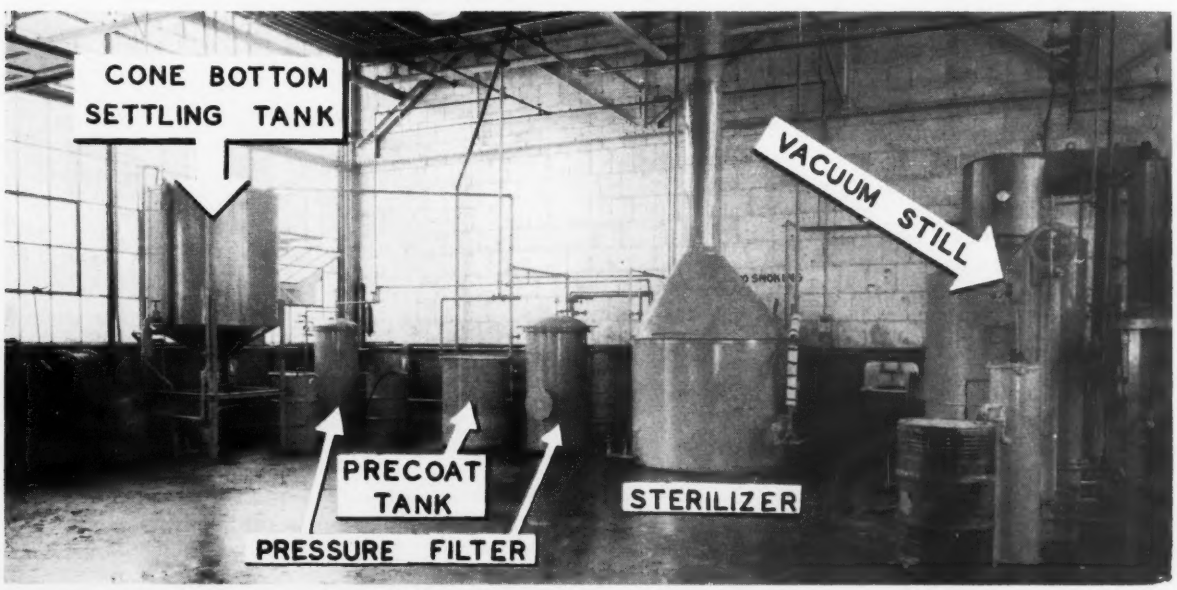
Following one of these tank wagons out into the shop reveals the highly developed plant-wide system that Cleaveland has built up in his 20 years of operation as the only resident lubrication engineer in the Bendix organization. First, on the way out, a typical first stop is to replenish the supply tank in one of many automatic cutting oil recirculating systems that serve groups of machines.

Next, after a refill at one of more than 100 strategically located remote storage tanks, many of them under ground, another stop will recharge fresh solvent into a cleaning tank or replenish the lube oil reserves maintained for the machine oilers.

On the return trip to the oil house, headquarters for the entire lubricant handling operation, used or contaminated materials are picked up for reclamation.

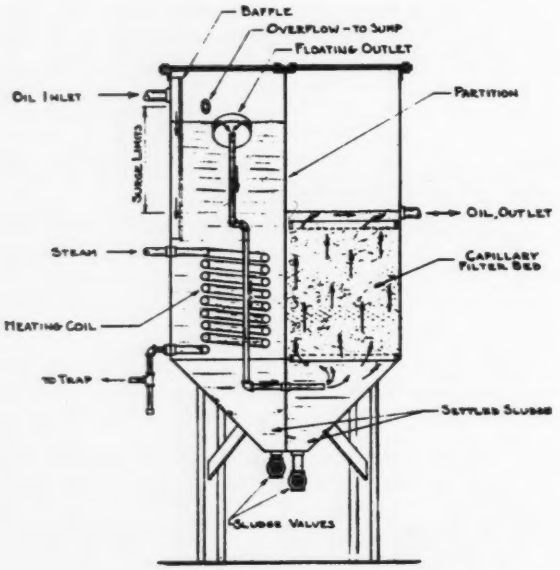
The oil house itself is a structure designed and equipped specifically for storage, handling and processing of the materials under the lubrication engineer's jurisdiction. Five bulk storage tanks keep 40,000 gal-

Department 32 Oil Stores of Bendix Products Division Vacuum Still and Oil Reclamation Center



lons of material in ready reserve, valved and piped for quick handling. Capacity for palletized storage, four-high, of more than 1,000 drums of the assorted materials required in smaller quantities is also provided.

But, conceding the necessity for storage and handling, the most important oil house activity is actually a production operation—reclaiming and compounding. Stills in continuous operation permit conservation of as much as 90% of used materials that would otherwise be scrapped and account for an average monthly saving to the company of more than $12,000.00.



Semi-automatic cutting oil reclamation system

Steam kettles are also provided for special compounding of cutting oils and coolants. Most of the special formula compounds used for various purposes in the plant are "home made" at a considerable saving. This assures not only the essential controls of the materials in use but also greatly reduces the number of different compounds that have to be stocked and, of course, provides a high degree of flexibility.

When Cleaveland first started the operation in 1941, a great number of different branded products were in use in various departments and had to be kept on hand. Now, even more widely divergent needs are met but storage is limited to a relatively small number of basic ingredients.

The underlying emphasis in the entire operation is on uniformity and control of lubricant use and application. There are two vital economic reasons for this emphasis.

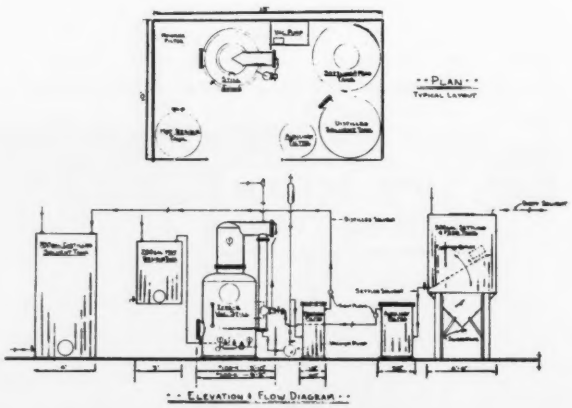
The first, conservation of material via reclamation, has already been mentioned. Plant-wide uniformity in the use of cutting oils and lubricants assures the volume of any given material that makes the operation of full-time reclaiming facilities practical. The second reason for emphasis on uniformity and control is almost as important in dollars and cents as is reclamation.

It is that uniformity, with the larger volumes of fewer different materials required, permits quantity purchasing at more favorable discounts. Monthly savings directly attributed to quantity purchasing at Bendix exceed $10,000.00.

Maintaining plant-wide uniformity and controlling the materials in use, especially in the absence of direct line dictatorial authority over production practices, is a give and take exchange. There's a great deal of selling and persuasion involved on the part of the lubrication engineer. And he doesn't always come out on top.

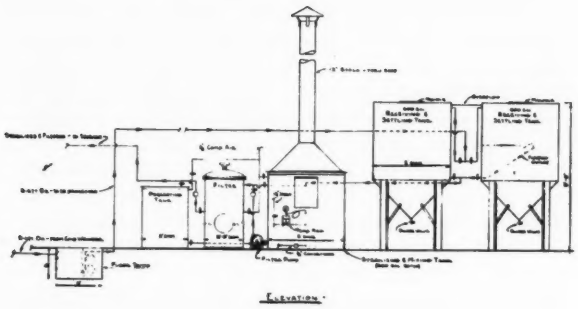
A case in point, and one that worked out to everyone's satisfaction in the end, concerned a changeover in certain plant areas from flammable to the newer fire-resistant hydraulic fluids. The switch was made at the insistence of the plant safety people without the whole hearted concurrence of the lubrication engineer. Cost of the new fluid was considerably higher and the safety gain could, in Cleaveland's opinion, have been equalled or even exceeded by means of other precautions without deviating from established practices in the use of hydraulic media.

After the change was made, it developed that even the lubrication engineer was pleased in a roundabout way. So much stress had been placed on the cost increases attendant upon the use of the new fluid that the equipment in which it was to be used was completely reworked to eliminate any possible leakage.



Vacuum distillation system for reclamation of both solvents and oils

Further, extremely careful handling procedures were set up. The net result, due to these precautions, was an actual saving in the cost of hydraulic fluid. Conservation through sparing and careful use more than offset the increased initial cost of procurement.



Batch type cutting oil reclamation system

In another case, the results were not so happy. A grinding coolant that seemed to offer certain advantages was put into use and apparently performed in accordance with expectations for some time. Then, luckily during a period when there were no workers in the area, a severe explosion occurred. The blast was traced to decomposition, with an accumulation of free hydrogen, of the new coolant.

Here, the safety people quickly joined the lubrication engineer in bringing about a return to use of the previously approved coolant. Incidentally, the safety director plays a role in the consideration of many lubricants, solvents and coolants at Bendix and is a member of the Chemical Committee.

This committee is composed of the lubrication engineer as chairman, the safety director, two chief chemists and four master mechanics. It passes on all new materials proposed for plant use and was formed to prevent just such occurrences as the one detailed above. No material, experimental or otherwise, may be used in production without authorization from this committee.

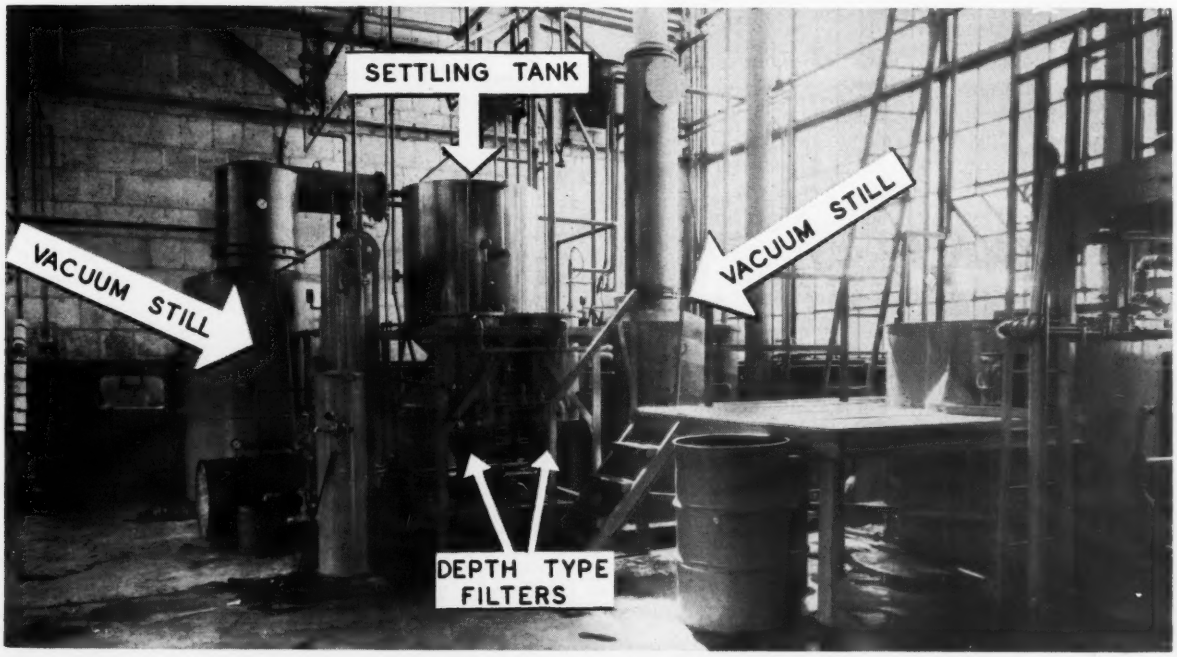
Another function of the committee is to eliminate the responsibility for one man decisions in connection with the acceptance or rejection of new material suggestions. This, of course, is of great help to the lubrication engineer and actually serves to reinforce rather than to dilute his authority.

THE ASSIGNMENT

Specifically, Dean M. Cleaveland as lubrication engineer at Benedix is charged with the investigation and recommendation, procurement, storage and distribution of all lubricants and related materials. Actual procurement is through regular purchasing channels but all determinations of type, quantity and delivery scheduling are made by Cleaveland. And because the main measure of his performance is in terms of dollar savings, his thinking and planning are fundamentally cost oriented.

In detail, the materials under the jurisdiction of the lubrication engineer include all lubricants, hydraulic fluids, cutting oils and coolants, thinners, solvents, testing fuels, heating oils and paints. In all,

Department 32 Oil Stores of Bendix Products Division Vacuum Stills



even with the emphasis on plant-wide uniformity of application and quantity purchasing, more than 500 separate items are involved.

To discharge this broad responsibility, Cleaveland is assisted by a crew of 35 men. About half of this force is engaged in the oil house production operation —reclaiming, compounding and distribution. The other half of the group, 18 oilers, was placed under the direct supervision of the lubrication engineer only about a year and a half ago in a move designed to assure properly scheduled and applied machine lubrication.

In addition to the day to day supervision and direction of his department, the lubrication engineer is also available for and spends a good deal of his time in consulting and trouble shooting at other Bendix divisions as well as the South Bend plant.

THE APPROACH

The methods and practices that Dean Cleaveland has evolved over the years are centered around the continual drive to maintain control and uniformity of lubricant use and application throughout the plant.

Specifications drawn up as standards for procurement and testing are purposely kept as broad and general as possible. This permits qualification of a larger number of suppliers for any given item so that purchases can be made on an advantageous competitive basis.

This practical breadth of basic specifications also makes it possible to accept incoming materials on the basis of supplier certification and eliminates a good deal of costly checking. Where detailed analysis does become necessary, it is performed by the company laboratories under the direction of the chief chemists who sit on the Chemical Committee.

Compounding of special formula materials as required is another effective way in which the lubrication engineer maintains plant wide uniformity. As previously mentioned, a few basic ingredients are stocked to permit manufacture and prompt delivery of almost any type of cutting oil needed. The necessity for testing and procuring a wide assortment of proprietary materials is greatly decreased.

The skill and facility in compounding that Cleaveland has developed at Bendix is apparent in his ability to meet consistently the demands of the production people for this or that advantage as claimed for some specific brand.

But despite generalized specifications and on the spot compounding, the number of different items to be stocked still runs to well over 500, as previously noted. To control this diversified stock adequately, a detailed card system for inventory control has been established. For each item on the stock list, a special inventory card is prepared to show the exact amount of the material on hand at any moment.

Further, carefully planned stock maximums and minimums for each item are noted on the inventory cards so that proper stock replenishment is an automatic feature of the inventory system.

Responsibility for the actual application of lubricants, with the crew of oilers, gives rise to another necessary record system. Individual cards detailing the locations and lubrication needs of more than 2,500 machines must be maintained to carry out a properly scheduled and systematic machine lubrication program. It was for just this purpose, to establish a lubrication program, that actual machine lubrication was placed under the lubrication engineer's direction.

In every detail of Cleaveland's operation, the effort and planning put into keeping all lubricant use and application under close control and in accordance with established plant practice is evident. There are many obvious reasons for this general approach to the lubrication engineer's function, but the basic reason is economy. Without plant-wide uniformity in the use of lubricants and cutting oils, maximum economy would be impossible. In essence the lubrication engineer's operation at Bendix Products is production (via reclaiming and compounding) and cost oriented as strongly as is any manufacturing or assembly department.

THE RESULT

The results achieved over the years when lubrication engineering is applied to all phases of use and handling in a plant as big as Bendix Products are really too numerous for listing. But, in general terms, here is a performance record that will stand up anywhere, by any standards:

1. Efficient reclamation procedures result in recovery and conservation of as high as 90% of certain materials that would otherwise be lost.
2. Directly traceable economies as a result of quantity purchasing, compounding and reclaiming run to approximately $25,000.00 per month—enough to make the lubrication engineer's department completely self-supporting on a production basis without considering the other cost reducing advantages accruing throughout the plant.
3. The emphasis on uniformity has led to extremely practical and simplified procedures in the use of lubricants. For example, only six basic viscosities of paraffin base material—80, 150, 180, 240, 300, 500 meet more than 90% of all machine and equipment lubrication needs.

Uniformity of use and application, conservation of materials and economy of operation are the watchwords in lubrication engineering at Bendix. In holding to these simple basics, Dean M. Cleaveland has proved that good lubrication engineering need not be considered a cost item—rather, it can be made a major factor in cost control.

A Survey of Lubrication Methods

Part 2
Lubrication Categories

by Allen F. Brewer*
Consulting Editor

Illustrated by Robert R. Wayne
Pittsburgh, Pa.

For classification purposes the methods for lubricating machine elements can be broadly grouped into the following categories:

Manual Devices
Drop Feed Oilers
Splash or Bath Lubrication
Ring, Chain, Collar Oilers
Pad and Waste Type Devices
Positive Force Feed Devices
Air-Oil Devices
Circulating Systems
Centralized Lubrication Systems
Built-in Lubrication

Although the devices within any category may differ quite markedly in outward physical appearance and detail, they have similar basic characteristics. The various categories will be discussed and their characteristics based on the criteria of Section I will be given.

MANUAL DEVICES

Every lubricating method requires human action in one form or another at some point in its operation. The amount and type of human action will vary depending on the particular lubricating method. For the purposes of classification, manual lubrication will be considered to apply to methods in which the operator is directly responsible for the quantity of lubricant applied to the bearing surface, the interval of lubrication, or both. If an operator is required periodically to maintain the lubricant level in a reservoir, but the quantity of lubricant reaching the bearing and the interval of lubrication is controlled mechanically, independent of the operator, the lubricating method is classed as manual.

Although the initial cost of manual lubrication is low, the maintenance costs can be very high. In addition, the reliability may be low due to the considerable dependence on human action.

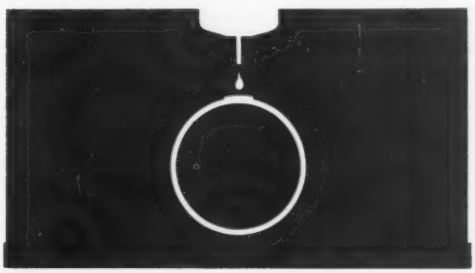
The manual method is also quite prone to contamination of the lubricant and can often result in poor housekeeping.

In general the flow of lubricant with manual devices is not too well regulated, non-uniform, non-adaptable, and non-continuous.

Generally speaking manual lubrication is only satisfactory for lightly loaded or low speed bearings and other machine elements that are infrequently used.

Typical applications include open gears, chains and wire rope and other inexpensive or rough machinery.

DROP FEED DEVICES



Drop feed oilers are gravity flow devices employed to deliver lubricant drop by drop to individual bearings or other machine elements. They are used to best advantage when the lubrication points are readily accessible and few in number.

The individual cost depends on the particular device in question, but generally speaking it is relatively low. The maintenance cost depends on the type of service and on the thought given in locating the device. For a large number of lubrication points, or for poorly accessible locations, the maintenance expenses can be quite high.

Depending on the particular device, the lubricant flow may or may not be stopped and started automatically. Automatic operation increases reliability.

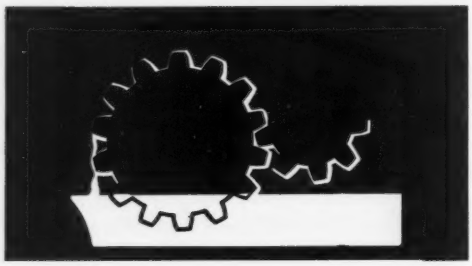
In general oil delivery from such devices can be characterized as being: gravity induced; variable with time (due to dependence of flow on the oil level in the device); non-adaptable; dropwise. Depending on the

* Consultant and author "Basic Lubrication Practice."

particular device regulation of flow may or may not be readily accomplished.

Typical service applications include journal and roller bearings, gears, chains, engine guides, pumps, compressors and pillow blocks.

SPLASH OR BATH LUBRICATION



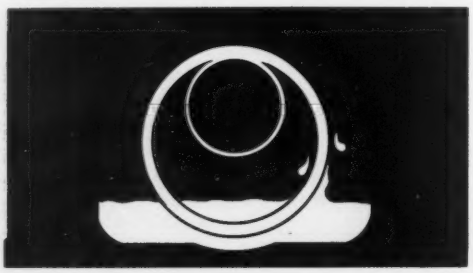
This type of lubrication is commonly used for machinery having high speed moving parts which dip into and splash oil to the bearings or other machine elements. A splash system requires that the mechanism to be lubricated be enclosed.

The initial cost of a splash system depends primarily on the expense entailed in enclosing the mechanism. The maintenance costs for splash systems are relatively low. A splash system is automatic, requires little operator attention and is quite reliable. The fact that the system is enclosed is conducive to preventing contamination of the lubricant. The lubricating oil is recirculated thereby making splash lubrication attractive both from the point of view of avoiding leakage and also as an economy.

In general the lubricant flow can be characterized as being fairly uniform, somewhat adaptable to changes in speed and fairly continuous. Regulation of flow is not possible other than by changing the level of the oil in the crankcase or by adding scoops or dippers to the machine element.

Typical applications include internal combustion engines, chain drives and enclosed gear sets.

RING, CHAIN AND COLLAR OILERS



These devices are applicable to horizontal rotating shafts. The ring or chain oiler encircles the shaft and is free to turn with it. The collar oiler is rigidly fixed to the shaft. Each provides an automatic oiling system for a bearing by circulating oil to the bearing clearance from the oil reservoir into which the device dips as it turns.

The initial cost of such devices depends primarily on the expense of the bearing housing that must be specially built to contain the devices. Maintenance cost during service is usually low.

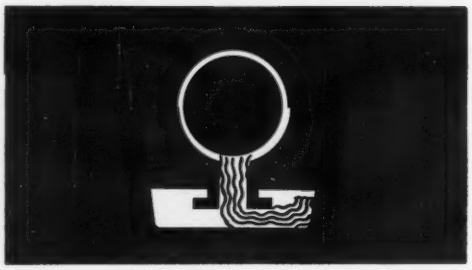
A ring, chain or collar oiler is reliable in service as long as the proper oil level in the bearing reservoir is maintained. When the bearing seal is tight, oil loss is small and the possibility of lubricant contamination is low.

The oil feed starts and stops automatically and the oil consumption is low as recirculation is readily accomplished.

In general, the lubricant flow can be characterized as being uniform, continuous and somewhat adaptable to changes in speed. Regulation of flow is not readily accomplished.

Typical applications include electric motors, fans, blowers, compressors and line shaft bearings.

PAD AND WASTE TYPE DEVICES



This type of lubrication utilizes the oil retaining properties of felt pads and waste packing to provide a lubricant source for a bearing.

In many applications the felt or waste wicking serves mainly as a link between a pool or reservoir of oil and the surface to be lubricated. The oil is lifted from the reservoir by the capillary action of the wicking material. The shaft or surface to be lubricant rubs against the oil soaked wicking and wipes off the required lubricant.

Such a system requires an appropriate housing which comprises a large portion of the initial cost of such devices.

The maintenance costs for such devices depends somewhat on the environment in which they are used, but generally speaking are low. In very dirty environments pad or waste type devices may require periodic

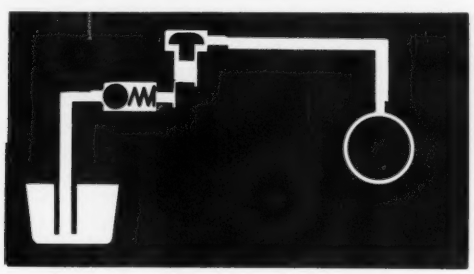
inspection to determine whether glazing or clogging of the wicking material has taken place to an extent that lubrication would be impaired.

The oil flow is automatic and the system usually permits recirculation of the lubricant. The wicking material serves to filter out contaminants, although as mentioned, excessive contamination may clog the wick. The lubricant flow can be characterized as being uniform, continuous and somewhat adaptable to speed changes. Generally speaking, regulation of delivery rate is not readily accomplished other then by changing the oil level in the reservoir.

This type of lubrication is often used for railroad and traction motor bearings.

In some other applications for space or economy reasons the felt pad or wicking material is required to hold all the available oil and no sump or reservoir of free oil exists. In general such devices require a simpler housing and involve a lower initial cost. Depending on the application relubrication may or may not be necessary, hence the maintenance expenses will be determined somewhat by the specific application. The rate of oil delivery from such a system is considerably less then that available when an oil reservoir is employed. The oil flow is automatic and the system usually permits recirculation of the lubricant. The oil flow is not uniform as it decreases as the degree of saturation in the wick decreases. Typical applications for such devices include the lubrication of sleeve bearings for fractional horsepower motors and the bearings used in various home appliances.

POSITIVE FORCE FEED LUBRICATORS



Basically a positive force feed lubricator is composed of one or more plunger-type adjustable-stroke pumps, that are mounted on a common reservoir.

The pumps are driven from a rotating shaft through a mechanical linkage. The shaft can be a part of, or connected to, the moving element of the machine being lubricated, or, it may have a separate drive motor.

The initial cost of a mechanical force feed device may be somewhat greater then some of the simpler devices, however the maintenance cost in service is low and the protection of the lubricant against contamination is excellent.

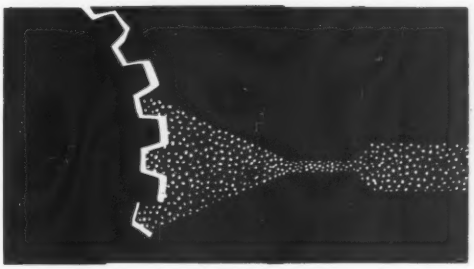
Generally the oil flow starts and stops as the machine starts and stops, thereby making the lubrication system automatic.

Regulation of oil flow is accomplished by adjusting the pump stroke. The oil delivery is uniform and adaptable to changes in speed. The flow is periodic rather then continuous.

As there is no provision for recirculation of the oil, the units are usually used on equipment that does not require a large quantity of lubricant in order to avoid frequent refilling of the reservoir.

Typical service applications of positive force feed oilers include steam cylinders, bearings for diesel and gas engines, oil drilling rigs, glass making machines and metal press bearings.

AIR-OIL DEVICES



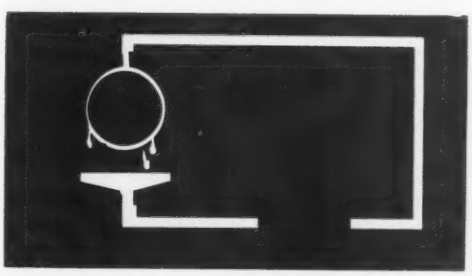
Air oil devices operate through the injection or pumping of oil drop-by-drop into an air stream or steam line, or by the drawing in of oil by the aspiratory action of compressed air in passing through a suitable orifice or control valve. The resultant air-oil mixture impinges on the bearing surfaces providing a lubricating film.

As compressed air and a suitable oil reservoir and piping system are required, the first cost of an air-oil system of lubrication could be relatively high. In service, however, maintenance costs are usually low.

Such systems can be made automatic by arranging to have the oil flow start and stop as the machine to be lubricated starts and stops. Oil delivery is positive and there is but remote possibility of contamination. There is no provision for recirculation of oil so this is a once-through form of lubrication. The rate of oil feed may be regulated.

An air-oil system is well suited for the lubrication of high speed bearings either plain or rolling contact, enclosed gears, chains, slides, guides and table ways.

PRESSURE CIRCULATING SYSTEMS

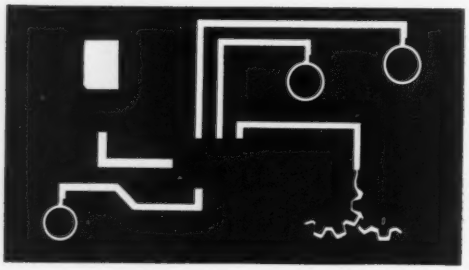


Pressure circulating systems for lubricating oils employ either gravity or pumps to develop the necessary driving pressures. Generally, a pressure circulating oil system is designed to lubricate a number of parts on the machine. Since the oil is recirculated, maximum oil economy is possible and good utilization of cooling by the lubricant is practicable.

Since a circulating system is built into the machine, the initial cost for piping, controls, pump and lubricant reconditioning equipment can be high, but the resistance of the system against entry of contaminants and its durability leads to quite low maintenance costs.

Once the various controls have been set, the operator need only to make routine inspections and add make-up oil when required. In the case of the systems employing pumps to circulate the lubricant the flow is positive. In general, circulating systems permit regulation of oil flow rate and delivery is uniform and continuous. Circulating systems are often employed where heavy duty bearings of a costly nature must be protected, and maximum dependability is desired. Typical applications of this type of lubrication include steam turbine bearings, reduction gears, steel mill gear drives and mill bearings; paper machine bearings and gears, and internal combustion engines.

CENTRALIZED LUBRICATION SYSTEM



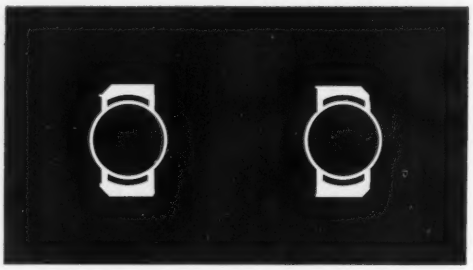
Centralized systems can be designed with either oil or grease as the lubricant. A typical centralized lubrication system requires a centrally located reservoir with suitable pump and permanently installed piping and distribution valves, to deliver measured quantities of lubricant to the various lubrication points. The system may be operated manually or else may be designed to dispense the lubricant at set intervals of time without requiring the presence of an operator.

Due to the piping details and intricate nature of the dispensing valves, the initial cost of such a system may be fairly high, but maintenance costs should be quite low if the system has been properly engineered. The initial cost is also offset by the dependability, durability, safety and the resistance of the system to lubricant contamination.

Centralized systems are generally made to start and stop automatically as the machinery being lubricated starts and stops. The lubricant flow is uniform, periodic rather than continuous, and can be regulated.

Centralized systems are ideally suited for steel and paper mills, machine tools and woodworking machinery which have a large number of lubrication points or lubrication points that are inaccessible or dangerous to service.

BUILT-IN-LUBRICATION



Built-in-lubrication refers to materials or components that do not require any external lubricating device to provide or replenish lubricants.

Certain materials such as oil saturated porous metals, graphited materials, PTFE, nylon and other plastics can, under proper conditions, be permitted to rub together without the necessity of adding a lubricant. These materials may be used for sleeve bearings, gears, sliding ways and similar devices.

Also included in this category are ball and roller bearings that are prelubricated by the bearing manufacturer and require no relubrication during their service life. Machine components having built-in-lubrication are well suited for use in inaccessible locations and in equipment where space or cost considerations dictate the use of components requiring no auxillary lubricating devices.

Devices utilizing built-in-lubrication can reduce maintenance when they are properly employed, however they are not cure-alls and should not be used indiscriminately. The operating conditions should be carefully checked to insure that the capacity of the device is not exceeded.

Look for Part 3
of this series

"Compendium of Lubricating Devices"

next month

"The Effect of Gamma Radiation on Aircraft Instrument Lubricating Oils"

by William L. R. Rice
Wright Air Development Center

This report gives an evaluation of the effects of gamma radiation on three aircraft instrument lubricating oils. Changes in the physical and chemical properties are shown as a function of increasing gamma exposure. Empirical equations are derived relating some of the observed property changes to the magnitude of the gamma dose.

Based on the property changes of the fluids, particularly at the higher dose levels, it appears that their use in a radiation environment would be questionable. Verification of fluid limitations through in-source evaluation in dynamic rigs is necessary.

It has been well established that organic fluids are particularly susceptible to the degrading effects of nuclear radiation. Therefore, to use such materials in an intense radiation environment requires pretesting to avoid in-service breakdown and subsequent system malfunction. This preliminary evaluation establishes the limits of use of conventional fluids and indicates the need for use of specialty materials. There are two ways to evaluate the radiation tolerance of fluids and lubricants. In the so-called "static" irradiation, the material in question is subjected to a series of radiation doses and then tested. Comparison of the properties with those of the control allows one to estimate the nature and magnitude of changes taking place. The second approach is to evaluate the materials in rigs operating in the presence of nuclear radiation. This dynamic evaluation allows a better esimate of usability and most closely simulates actual operating conditions. Dynamic evaluation generally follows screening tests performed under static conditions. This eliminates materials of obviously poor radiation stability and enables concentration of research efforts on the more promising materials.

This report concerns an evaluation made of the effects of static exposure to gamma radiation on three aircraft instrument lubricating oils. It is intended to give an indication of the gross effects of the gamma radiation on the fluids and to show where one might expect difficulties in their use in a radiation environment.

MATERIALS AND PROCEDURE

The lubricants reported herein were all qualified under specification MIL-L-6085, entitled "Lubricating Oil; Aircraft Instrument, Low Volatility." All samples were drawn from Air Force stock for the radiation effects study. Fluids of this type are generally composed of a diester base fluid inhibited against oxidation, and possessing rust-preventive properties. They are intended for use in the lubrication of aircraft instruments and electronic equipment. These fluids were not developed for use in a radiation environment. Therefore, the data presented herein are not to be construed in any way as limiting their applicability for use under their intended design conditions.

Appendix 1 gives a summary of the test methods used. Said methods are standard and will not be discussed herein. Irradiations were conducted in the spent fuel elements canal of the Materials Testing Reactor, Idaho Falls, Idaho. Details of the facility are given in reference (8). Doses were originally in terms of the roentgen. They were converted to ergs per gram carbon assuming one roentgen equivalent to 87.1 ergs per gram carbon.

RESULTS AND DISCUSSION

The data obtained are given in Tables 1, 2, and 3, and plotted in Fig. 1 through 6. Where two columns of data are shown for one dose, it represents two samples of the fluid irradiated and tested individually.

The effects of the gamma radiation on the instrument oils are characteristic of those noted for diesters in previous studies (2, 4, 5, 6, 8, 9, 10). For example, Fig. 1 shows that the viscosity of the fluids increases markedly at doses above about 1×10^{10} ergs per gram carbon. (Ergs/gm C.) This general break point is typical for all but the most stable organic fluids.

Fig. 2 shows the change in flash point with increasing radiation exposure. The flash point falls off with increasing dose levels above about 1×10^{9} ergs/gm C. Over a wide range, this decrease is approximately linear with the logarithm of the dose. The general relationship is

$$y = 194(11.674 - \log x) \qquad [1]$$

where y is the flash point (°F) and x is the gamma dose (ergs/gm C). (Appendix 2 gives the calculations for all equations) Since the flash point can be lowered by contaminants or volatile constituents, the observed relationship is undoubtedly due to the formation of breakdown products by irradiation.

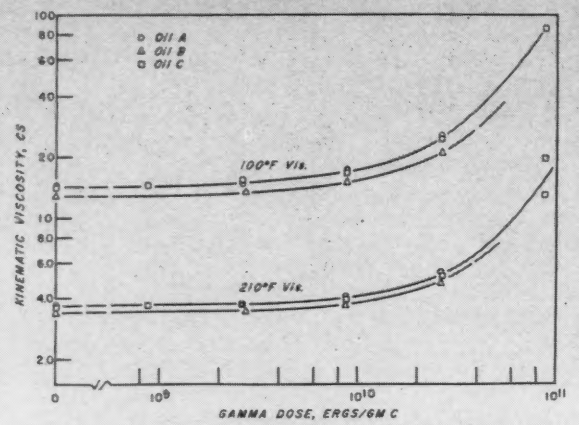


Fig. 1. Effect of Gamma Radiation on Viscocity

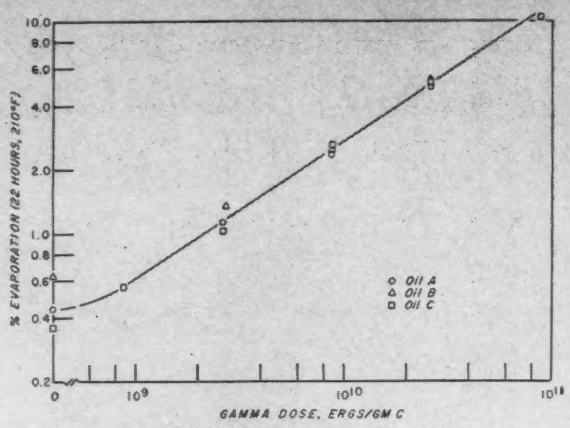


Fig. 4. Effect of Gamma Radiation on Evaporation

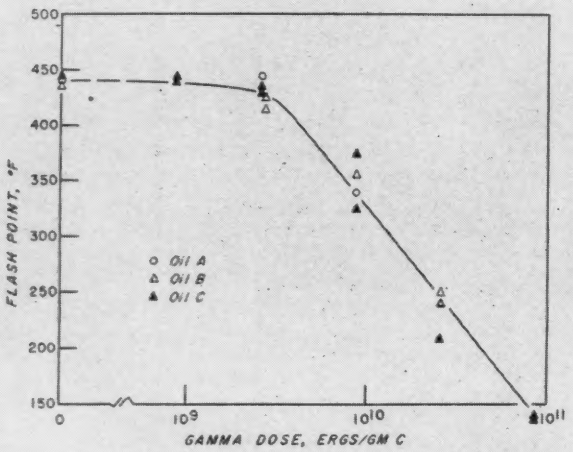


Fig. 2. Effect of Gamma Radiation on Flash Point

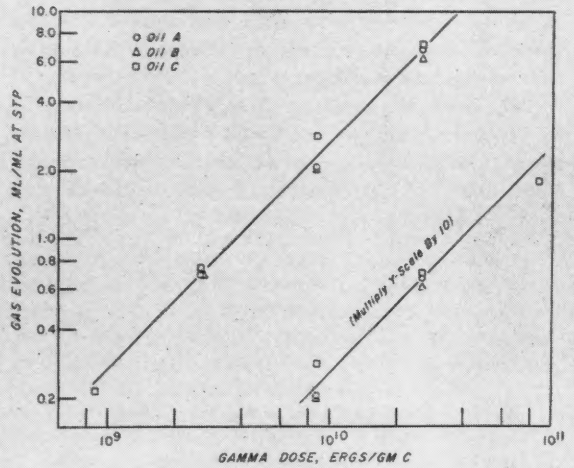


Fig. 5. Effect of Gamma Radiation on Gassing

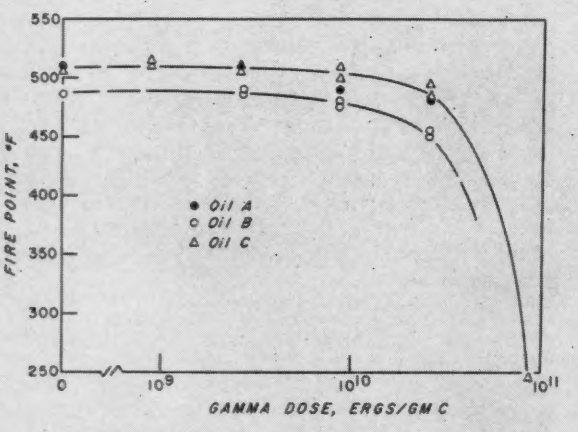


Fig. 3. Effect of Gamma Radiation on Fire Point

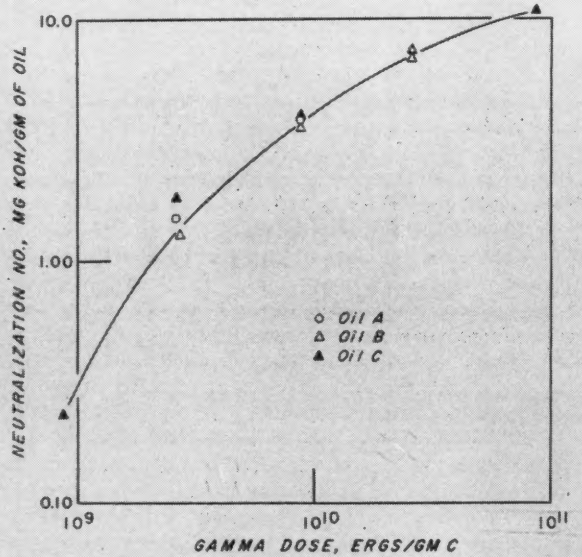


Fig. 6. Effect of Gamma Radiation on Neut. Number

Fire point also drops with increasing dose, as shown by Fig. 3. The change here does not become significant until about 1×10^{10} ergs/gm C. Apparently the breakdown products formed do not have a pronounced effect on the fire point until much greater degradation has taken place.

Evaporation tendency increases with exposure, as shown in Fig. 4. It follows a power function of the form

$$y = \text{antilog}(0.634 \log x - 5.92) \qquad [2]$$

where y is the per cent evaporation and x is the dose in ergs/gm C. This again shows the effect of radiation on the formation of volatile products.

Gas evolution is characteristic of all irradiated fluids. Fig. 5 shows the gas evolution of the instrument oils as a function of the radiation dose. Although the values are not too precise, being calculated from the canister pressure and gas volume, a relationship can be obtained having the form

$$y = 2.6 \times 10^{-10} x \qquad [3]$$

where y is the gas evolution (ml/ml at STP) and x is the gamma dose (ergs/gm C). The data were not precise enough to determine if the exponent of x is indeed unity, as it appeared, so it is not certain whether the relationship should be linear or a power function.

Acidic products are formed with increasing dose, as shown in Fig. 6. Neutralization numbers in excess of ten are observed at about 1×10^{11} ergs/gm C. This large increase in acidic content is in accord with previous observations (2, 8, 10).

Perhaps the greatest change in the fluids was in the oxidation-corrosion characteristics. Tables 1, 2, and 3 show that metal corrosion became excessive at very low dose levels. For example, cadmium was attacked severely at levels below 1×10^9 ergs/gm C. Copper also showed strong corrosion and the other metals displayed corrosion at the higher dose levels. The neutralization numbers showed very great changes, even when compared to the values for the unoxidized fluids. The 210F viscosity increased markedly as a result of the test. For the higher doses, it increased over

TABLE 1—Effect of Gamma Radiation on Oil A

Gamma Dose (ergs/gm C)*	0	2.61×10^9	8.71×10^9	2.61×10^{10}
Viscosity (cs)				
210F	3.69	3.73	4.06	5.34
100F	14.4	14.9	17.2	25.7
−40F	1,812	1,969	2,509	5,269
Pour Point (°F)	< −85	< −85	< −85	< −85
COC Flash Point (°F)	440	445	340	240
COC Fire Point (°F)	510	510	490	480
Evaporation, % (210F, 22 hours)	0.44	1.13	2.35	4.96
Gas Evolution (ml/ml at STP)	0	0.69	2.04	6.68
Oxidation-Corrosion**				
Metal Weight Loss (mg/cm²)				
Magnesium	0.016	0.016	0.135	1.812
Aluminum	0.000	0.000	0.000	0.016
Copper	0.152	9.045	3.828	7.758
Cadmium	0.033	10.121	24.596	46.906
Steel	0.033	0.000	0.000	1.016
Neutralization Number				
Before	0.05	1.51	3.86	7.44
After	1.51	4.20	9.85	16.35
Change	1.46	2.69	5.99	8.91
Increase in 210F Viscosity, %	8.4	10.2	52.5	58.4
Evaporation loss, %	0.28	1.55	0.26	4.45

* MTR Gamma Canal
** Miniaturized, 168 hours at 250F

TABLE 2—Effect of Gamma Radiation on Oil B

Gamma Dose (ergs/gm C)*	0	2.70×10^9		8.71×10^9		2.61×10^{10}	
Viscosity (cs)							
210F	3.36	3.44	3.45	3.70	3.73	4.80	4.72
100F	12.8	13.4	13.7	14.9	15.2	21.6	20.8
−40F	3848	1577	1558	1972	1988	4153	3848
Pour Point (°F)	< −85	< −85	< −85	< −85	< −85	< −85	< −85
COC Flash Point (°F)	435	415	425	355	355	240	250
COC Fire Point (°F)	485	490	485	480	475	450	455
Evaporation, % (210F, 22 hours)	0.63	1.37	1.32	2.48	2.53	5.26	5.27
Gas Evolution (ml/ml at STP)	0	0.65	0.72	2.14	1.87	7.06	5.25
Oxidation-Corrosion**							
Metal Weight Loss (mg/cm²							
Magnesium	0.033	0.016	0.050	0.033	0.084	1.510	1.609
Aluminum	0.016	0.016	0.033	0.033	0.016	0.016	0 000
Copper	0.101	1.626	2.693	1.609	1.592	2.693	4.065
Cadmium	0.101	31.101	33.795	33.083	41.839	38.386	39.029
Steel	0.050	0.000	0.033	0.033	0.033	0.474	0.067
Neutralization Number							
Before	0.19	1.28	1.30	3.24	3.86	7.00	6.88
After	0.39	11.98	14.22	14.56	12.55	13.16	14.00
Change	0.20	10.70	12.92	11.32	8.69	6.16	7.12
Increase in 210F Vis. (%)	1.6	21.4	23.5	26.5	46.2	44.5	42.4
Evaporation Loss (%)	0.49	2.21	2.50	2.41	2.30	3.81	4.07

* MTR Gamma Canal
** Miniaturized, 168 hours at 250F

TABLE 3—Effect of Gamma Radiation on Oil C

Gamma Dose (ergs/gm C)*	0	8.71×10^8		2.61×10^9		8.71×10^9		2.61×10^{10}		8.71×10^{10}	
Viscosity (cs)											
210F	3.59	3.74	3.62	3.74	3.73	3.94	4.00	5.16	5.13	19.75	13.10
100F	14.2	14.5	14.4	15.5	15.1	16.6	17.0	24.1	24.9	121.7	85.1
−40F	1781	1806	1801	1917	1981	2360	2478	4729	1852	66,954	38,631
Viscosity Index	157	170	157	152	158	157	157	155	148	142	137
Pour Point (°F)	<−85	<−85	<−85	<−85	<−85	<−85	<−85	<−85	<−85	−75	−75
COC Flash Point (°F)	445	440	445	430	435	375	325	210	210	140	135
Fire Point (°F)	505	515	510	510	505	500	510	485	495	245	245
Evaporation, % (210 F, 22 hours)	0.36	0.53	0.59	1.05	1.02	2.29	2.90	5.35	5.04	10.65	10.11
Gas Evolution, ml/ml at STP	0	0.22	0.21	0.67	0.80	2.52	3.08	2.57	6.50	18.0	17.8
Oxidation-Corrosion**											
Metal Weight Loss (mg/cm^2)											
Magnesium	0.000	0.016	0.000	0.016***	0.254***	0.016	0.016	0.643	0.084	6.488	5.336
Aluminum	0.000	0.016	0.000	0.000	0.083***	0.033	0.016	0.033***	0.033***	0.016	0.016
Copper	0.050	1.998	1.981	3.794	1.846	0.982	5.641	7.165	1.863	0.931	1.270
Cadmium	0.016	4.556	6.792	25.426	28.899	33.371	41.198	55.224	56.613	36.895	39.046
Steel	0.000	0.033	.016	0.016	0.000	0.033	0.965	0.203	0.220	1.253	2.168
Neutralization Number											
Before	0.01	0.19	0.27	1.76	1.90	3.97	6.91	7.67	7.78	10.47	11.25
After	0.05	2.24	2.96	9.74	10.08	11.98	12.88	16.57	15.68	8.40	9.82
Change	0.04	2.05	2.69	7.98	8.18	8.01	5.97	8.90	7.90	−2.07	−1.43
Increase in 210F Viscosity, %	0.8	0.3	−2.0	15.3	16.4	23.9	23.0	70.2	62.7	313.2	276.2
Evaporation Loss, %	0.25	0.53	0.27	1.80	1.82	2.05	2.67	5.23	4.50	7.04	7.46

* MTR Gamma Canal
** Miniaturized, 168 hours at 250F
*** Gain

fifty per cent. The evaporation loss during the test was increased somewhat for the irradiated fluids. The data indicate in general that there is a great decrease in oxidative stability of the inhibited fluids due to irradiation. This loss is typical for inhibited ester or diester blends (6).

SUMMARY

Gamma radiation has an appreciable effect on aircraft instrument lubricating oils. Most of the physical and chemical characteristics are degraded, some of them to the point that satisfactory use would not be predicted. Probably the greatest change is in the effect of the irradiated fluids on metals during oxidation-corrosion. The excessive attack on cadmium would exclude this metal from use in instruments using these oils in an oxidizing atmosphere. The same would be true of copper. The increase in acidity would lead one to expect compatibility problems with such materials as elastomers or plastics, due to possible attack. The evidence for formation of volatile fragments would indicate a possible increase in fire hazard, while the observed gas evolution might present a problem in sealed systems due to pressure increase.

The results obtained are sufficient to show that all three fluids would be questionable for use in a radiation environment to very high dose levels. Their usability must be determined in in-source operation of aircraft instruments and electronic equipment. Since none of the three fluids appear appreciably better, choice of the test fluid for more extensive evaluation would be arbitrary.

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"Test Procedures for Compounds Used as Preservatives in Industrial Coolants"

by L. J. Brandeberry and H. V. Myers, Jr.
The Ford Motor Company

"The purpose of this paper is to present one acceptable laboratory screening procedure and actual shop trial application with data to show the efficacy of a selected antibacterial agent for use in industrial coolants.

Results of the shop trial application confirm the reliability of the laboratory screening test and show that the antibacterial agent, tris (hydroxymethyl) nitromethane, can be used effectively to control bacterial growth in coolants."

Bacterial contamination of cutting oil emulsions and other types of coolants often cause serious problems. Among these are:

1. Excessive waste treatment
2. Odor formation
3. Emulsion breaking
4. Dermatitis and infection
5. Staining and corrosion of metal parts

Much has been written about the last four problems and various compounds used to overcome them as well as the various test methods used to screen such compounds and test their efficacy in plant use (1, 2, 3, 5, 6, 7, 8, 9). However, the importance of satisfactory bacterial control in coolants as related to industrial waste treatment cannot be over emphasized. It should be recognized that adequate bacterial control extends coolant life, reduces the frequency of discards, reduces the size of waste treatment facilities and results in over-all economy. In effect, these factors can, in many cases, be the principal reason for the use of an antibacterial agent in the coolant.

This paper describes one method used for screening compounds proposed as antibacterial agents in cutting oil emulsions, and for checking their usefulness by actual shop trial.

It seems quite generally agreed that there are no laboratory tests which give completely satisfactory answers as to a compound's utility in inhibiting bacterial growth in coolants of this type under plant conditions. However, it was found that a series of screening tests based on two or three criteria gives a good indication of the utility to be expected from a compound under plant conditions. Also, these same criteria furnish a convenient gauge to judge the conditions of the systems being used in the plant. These criteria are:

1. Total bacterial population
2. Coliform bacteria count
3. Presence of sulfate-reducing bacteria

Total bacterial population, or total plate count, is perhaps the most important of the three criteria. A high count in some systems does not necessarily indicate that trouble will be encountered, but suggests the likelihood of odor development, pH reduction and change in the physical properties of the coolant. Experience has indicated that a total count of about 3.0×10^7 organisms per milliliter is indicative of probable difficulties.

A high coliform count taken by itself is also not necessarily an indication of impending trouble. It has been found, however, that in many cases, a high coliform count is indicative of a high total bacterial count. These organisms are of interest from a general sanitation standpoint and are used as an indication of pollution by Departments of Public Health. The resistance of the coliform organisms to a disinfectant is an excellent measure of its effectiveness. Also, this is a rapid and easy test to use. Counts in coolants in excess of 1.0×10^4 organisms per milliliter are considered to be excessive.

Sulfate-reducing bacteria are of particular importance. The presence of these organisms in coolants causes the development of dark color, hydrogen sulfide odor, and corrosive properties. This type of growth is particularly likely to occur during shut-down periods and often after prolonged use of a coolant system without disinfectant control.

The methods used in applying these criteria to the laboratory screening of potential antibacterial agents are illustrated by tests using tris (hydroxymethyl) nitromethane. The procedure is as follows:

(A) *TOTAL PLATE COUNT*

For studying the effect of the antibacterial agent on the total bacterial population, 5 ml. portions of water containing varying amounts of the antibacterial

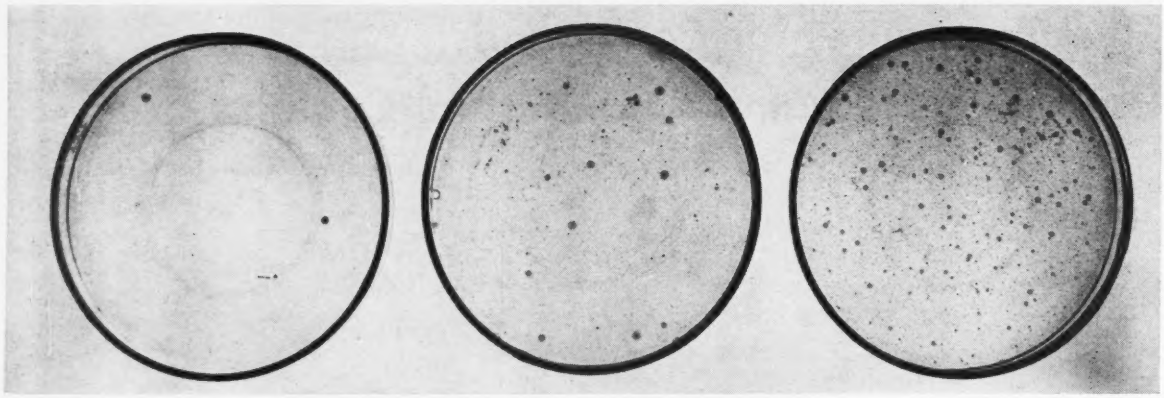

Fig. 1. Typical Total Plate Count on a System having Approximately 19,200,000 Bacteria Per Milliliter on Bacto Agar.
Left **1 X 10^{-4} ml.**
Center **1 X 10^{-5} ml.**
Right **1 X 10^{-6} ml.**

agent are added to 195 ml. portions of a 1/50 cutting oil emulsion from a system which has been in use for some time, and which is known by tests to contain a high total plate count. Dilutions of the agent generally used are 1/1000, 1/1500, 1/2000 and 1/3000. At the same time, a control is prepared with no antibacterial treatment. After 0 and 24 hours, or other suitable time intervals, inoculations are made from each, using 1 ml. portions of aliquot mixtures, into Bacto Nutrient Agar. The plates are then incubated for 48 hours at 37 C and the total bacterial count determined.

Fig. 1 shows a typical total plate count on a system having about 19,200,000 bacteria per milliliter.

(B) *COLIFORM BACTERIA COUNT*

For this test a modification of the method described by Gehm and Heukelekian (4) is used. To 195 ml. portions of a 1/50 cutting oil emulsion (same source as A), 5 ml. portions of water containing varying amounts of the antibacterial agent to give dilutions of 1/1000, 1/1500, 1/2000, and 1/300 are added. A control is also prepared with no treatment. The bacteriological analysis is then made by use of previously prepared Eosin Methylene Blue Agar plates with the media about 3 mm to 4 mm deep. This media requires 36 grams of Bacto Eosin Methylene Blue Agar and 4.5 grams of Bacto Nutrient Agar to one liter of distilled water. After 0, 4, and 24 hours, or other suitable increments of time, inoculations of 1 ml portions of aliquot mixtures of the prepared samples are made to the surface of the prepared E. M. B. Agar plates. The plates are then dried in the incubator with the covers removed. Periodic gentle rotation results in uniform drying and good distribution of bacteria over the entire surface of the media. Drying requires about one hour. The covers are then replaced, the plates inverted and incubated at 37 C for 24 hours, after which all characteristic coliform colonies are counted and the total count determined.

Fig. 2 shows a coliform count on the same system as was shown in Fig. 1. The coliform count here was about 77,000 organisms per milliliter. These figures illustrate the correlation of high coliform count with high total count.

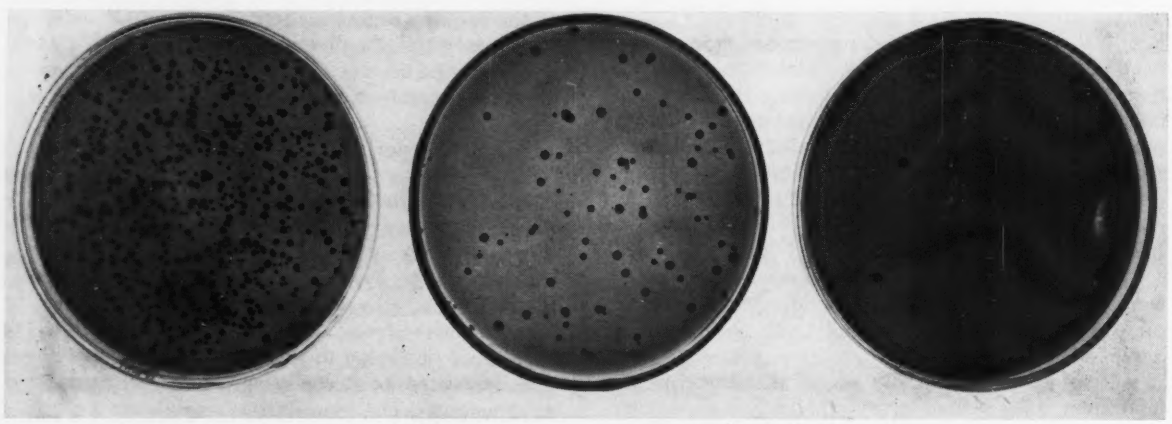

Fig. 2. Typical Total Plate Count on a System having Approximately 77,000 Coliform Organisms Per Milliliter on E. M. B. Agar.
Left **1 X 10^{-2} ml.**
Center **1 X 10^{-3} ml.**
Right **1 X 10^{-4} ml.**

(C) *SULFATE-REDUCING ORGANISMS*

The presence of sulfate-reducing organisms is checked by the procedure described by Bennett (2). Varying portions of inoculum from 0.1 to 5 ml are used. The results of this test are rated from 0 for no growth to 4^+ for very heavy growth.

SCREENING TEST

Results of a screening test which were used as a basis for a plant trial are shown in Table 1:

TABLE 1—BACTERIOLOGICAL ANALYSIS ON SCREENING TEST

	COLIFORM COUNT PER ML.			TOTAL BACT. COUNT PER ML.	
SAMPLE	START	4 HOUR	24 HOUR	START	24 HOUR
Control	1.9×10^4	1.8×10^4	2.1×10^4	4.5×10^6	5.2×10^6
1/1000	1.9×10^4	1.7×10^4	0	4.5×10^6	1.3×10^3
1/1500	1.9×10^4	2.0×10^4	0	4.5×10^6	1.0×10^3
1/2000	1.9×10^4	2.0×10^4	0	4.5×10^6	1.0×10^3
1/3000	1.9×10^4	2.0×10^4	0	4.5×10^6	3.1×10^3

PLANT TESTS

The first plant tests were conducted by adding the antibacterial agent to three coolant systems known to be contaminated. The concentration varied due to the fact that only 200 pounds of the antibacterial agent was available at the time. Results of the initial treatment are shown in Table 2:

TABLE 2—BACTERIOLOGICAL ANALYSIS ON FIRST SHOP TRIAL

ANTIBACTERIAL CONC.	TYPE OF TEST	BACTERIOLOGICAL ANALYSIS				
		INITIAL	24 HRS.	5 DAYS	19 DAYS	33 DAYS
1/1100	Coliforms per ml.	3.5×10^5	8×10^2	0	1.5×10^3	4.8×10^4
	SO_4 Reducers	+	+	0	0	0
1/1475	Coliforms per ml.	1.7×10^4	3×10^2	0	7.0×10^2	2.4×10^4
	SO_4 Reducers	+	+	0	0	0
1/1150	Coliforms per ml.	6.9×10^4	1×10^2	0	4.0×10^2	7.2×10^5
	SO_4 Reducers	+	+	0	0	0

No supplemental treatment was added to any of the systems during the test even though coolant losses were made up as required.

Based on the results obtained, tests were conducted on several different systems to establish the duration of the activity of the disinfectant. This time, the coliform count, total bacterial count, and the presence of sulfate-reducers were all checked. Results from one location are shown in Table 3:

TABLE 3—BACTERIOLOGICAL ANALYSIS ON SECOND SHOP TRAIL

ELAPSED TIME	ANTI-BACTERIAL AGENT ADDED (LB.)	COLIFORM COUNT PER ML.	TOTAL BACTERIA COUNT PER ML.	SO_4 REDUCERS
	(Before treatment)	3.0×10^2	5.6×10^7	+++
	91 lb.	...	...	...
1 day	...	0	7.7×10^6	0
5 days	...	0	8.5×10^3	0
8 days	...	0	1.2×10^5	0
12 days	...	0	1.1×10^5	0
15 days	...	0	1.9×10^5	0
26 days*	...	1.9×10^3	1.3×10^5	0
33 days	...	2.5×10^5	1.0×10^7	+
34 days	91 lb.	...	...	...
40 days	...	4.0×10^2	2.2×10^5	0

Capacity of system—11,000 gal.
* Plant closed down for one week.

DISCUSSION

In this series of tests, the control achieved on the preliminary screening test made the test for sulfate-reducers unnecessary. However, it seemed advisable to include it in the first plant run.

The plant test shows confirmation of the results in the preliminary tests. The antibacterial agent controlled all three phases satisfactorily at a concentration of 1/1000 for thirty-three days, although this system is one which becomes highly contaminated in a few days if not treated.

It should be emphasized that plant tests must be conducted in systems of known characteristics in order to be significant. Experience has shown that different coolant systems vary widely in their tendencies toward contamination. These differences are probably related to such factors as aeration; relation of volume of coolant to the amount being circulated; composition of coolant; nature of the machining process; type of stock; etc.

These three tests showed the antibacterial agent to be a satisfactory additive for controlling bacterial contamination of coolant emulsions.

Further criteria of importance in evaluating compounds for possible use in coolant emulsions are cost, toxicity, odor, effect on emulsions, and ease of disposal when the system is cleaned.

The formula for tris (hydroxymethyl) nitromethane is $(CH_2OH)_3C\ NO_2$, and this compound slowly gives off formaldehyde at the pH range (8.0 to 9.5) encountered in most coolant emulsions. These results indicate that the formaldehyde thus released plays a role in whatever way tris (hydroxymethyl) nitromethane acts to control bacterial growth. There

(*Con't. on page 170*)

A comprehensive cutting fluid evaluation program is described which includes preliminary screening tests and machinability tests.

The screening tests insure that only products possessing superior physical properties are considered for further evaluations. The machinability tests consist of a full scale lathe turning test to compare cutting fluid performance. Statistical methods are used to determine the reliability of test data and to establish levels of significance for comparing cutting fluids. Results have shown good correlation with field experiences.

Test Procedures for the Evaluation of Cutting Fluids

by R. J. Yanis and G. F. Wolfe

General Electric Co.

INTRODUCTION

The need for the establishment of a formal cutting fluid evaluation program became urgent several years ago. At that time, within a twelve-month period, seventy-eight cutting fluids were submitted for use in the departments machining operations. Formulations included all sorts of chemical combinations thought to have desirable effects for metal cutting. Prices ranged from 30 cents per gallon to as high as $5.00 per gallon. The only means of evaluating these cutting fluids were shop trials on production work. Such trials proved to be ineffective and costly. They were ineffective and misleading because of the lack of control over other variables which had greater effect on results than did the cutting fluid being tested. Yet, because of the lack of any other testing procedures, cutting fluids were selected on the basis of the results of such shop tests. These shop tests were costly because production machines had to be interrupted and the variety of answers obtained from different trials led to the purchasing and stocking of numerous types of cutting fluids. This resulted in high costs due to low quantity orders; high prices paid for some cutting fluids; machine and workpiece damage due to certain fluids; and the considerable time spent with vendors who sought to have their cutting fluids tested. It was not possible to test more than a small portion of the available cutting fluids since some tests lasted as long as eight months. Therefore, in a situation such as this, the most desirable cutting fluids from both a cost and performance standpoint could easily have been overlooked. Besides, the results of such tests increased confusion instead of knowledge concerning the effects of cutting fluids.

All of these problems pointed to the need for a better way of evaluating cutting fluids. Since shop testing technique was not satisfactory, the problem was turned over to the department laboratory. Although some type of a plant test would be required as a final measure of a coolant success, it was obvious that the plant could not be used successfully as a screening laboratory. Because of the great number of cutting fluids involved, the first step was to find some quick means of eliminating as many of the less desirable fluids as possible from further consideration.

Presented before the 14th ASLE Annual Meeting, Buffalo, New York, April, 1959.

PHYSICAL TESTING OF CUTTING FLUIDS

A large percentage of water soluble cutting fluids are eliminated by subjecting them to a series of screening tests. Each one of these tests is regarded to have so much importance from a shop and quality maintenance point of view and also from a health standpoint, that the acceptance of a cutting fluid is conditional upon satisfactory performance in such tests. The significance and value of these tests have been established since the results have correlated with production experience. Fluids that have failed any one of these tests have caused maintenance difficulties in the plant. Several of the more important tests are described as follows:

1. *Rusting Tests*

   A humidity test, using a desiccator as a chamber, was selected for use in this investigation. A saturated solution of ammonium sulfate is placed in a large desiccator (12 inches O.D.). This solution will produce a humidity of 81% within the closed desiccator at a temperature range of 70-85 F.

S.A.E. No. 1018 steel specimens, three inches long and one inch in diameter, are used for the test. These steel specimens are ground at one end to a clean bright finish using an 80 grit sanding belt on an electric sanding machine. The size of grit used did not influence the results obtained with this test. The steel specimens are washed with Xylene and Acetone, dried and used immediately. Two separate rusting tests are performed. A twenty to one mixture of the soluble metal cutting fluid to be tested is prepared using tap water. The

mixture is stirred by hand for two minutes and applied as follows:

a. *Single Specimen Rusting Test*

A steel slug is placed in the desiccator with the polished surface on top. Ten drops of the 20:1 emulsion are placed on the polished surface. The desiccator is then closed and the polished surface of the slug is observed periodically for evidence of rust. A good soluble cutting fluid will protect the polished surface from rust for three weeks under the imposed humidity conditions.

b. *Matched Specimen Rusting Test*

The second rusting test is called a matched specimen test. In this procedure, the same amount of test fluid mixture is transferred to the polished end of a steel specimen outside the desiccator. The polished end of a second specimen is then placed on top of the polished end of the specimen containing the emulsion. The polished surfaces are then separated only by a thin film of the cutting fluid. The stacked specimens are then placed in the desiccator. This is a very difficult rusting test for a fluid to pass. A good soluble fluid will protect the polished surfaces from rust for 48 hours.

2. *Fluid Stability*

The next test is an evaluation of fluid stability. In Lynn, the water supply has a hardness of only 15-20 ppm as $CaCO_3$ and the actual breaking of an emulsion due to dissolved salts in the water has not been a problem. All that is done in this test is to take 100 ml of a 20:1 tap water mixture of the fluid and allow it to stand for one week. Any separation of the emulsion is noted. Some "creaming" on the surface is permitted but no oil separation should occur. In some instances, when "all chemical" fluids are evaluated in this manner, it has been noted that a component has settled out after standing one week. In some cases, mold growth occurred. Obviously, both conditions constitute a failure. The test has little practical significance since most fluids appearing on the market today have been found to be quite stable.

3. *Mold and Odor Formation Test*

Cutting fluids used in production operations have a tendency to spoil or go rancid, resulting in objectional odors which are a source of complaint from workers. Our "Monday morning odor" problems have been greatly reduced as a result of a thorough periodic machine cleaning program. Our plant experience has indicated that certain soluble cutting fluids resist rancidity for longer periods of time than others. Since the emulsion stability test has little practical significance and does not predict the behaviour of a product in production operations, it was important to develop a new, simple stability test which would differentiate between products and relate to plant performance. As a result, the fluid stability test was modified in such a way that it would evaluate fluid properties under conditions of contamination which stimulate actual use. Many types of contaminates were evaluated and the material that was finally selected was plain yellow corn meal. Two grams of corn meal are added to 50 ml of a 20:1 fluid mixture. The solution is set aside in the dark and examined periodically for evidence of mold and odor formation. A good soluble cutting fluid will last 21 days without going "sour." The behavior of different cutting fluids in the test is remarkable. A definite dark colored mold starts to form on the surface of the solution after approximately five day's storage. In some cases, the entire surface may be covered with mold by the end of the test. The mold formations are usually accompanied by very foul odors. Contamination of solutions with corn meal definitely provides some indication as to how fluids will fare in the plant where all forms of contamination are possible. The correlation of this corn meal test with plant performance has been good. Our experience has shown that fluids which have caused odor problems in the plant readily produce mold and odor in this test. Using this procedure, the stability of the fluid can also be determined by measuring the change in pH of the contaminated solution with time. This is illustrated in Fig. 1. The pH of the unstable fluids changes very rapidly. Stable fluids show a relatively minor decrease in pH with time. This occurs in spite of initial buffering.

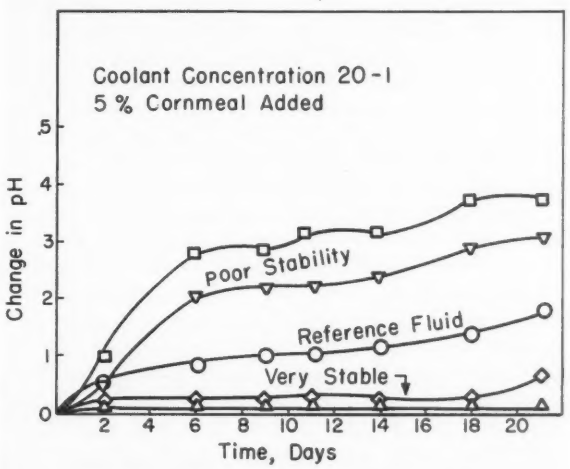

Fig. 1. Change in pH with time for various cutting fluids.

Today, relatively little information is known about the action of specific germicides on mold growth or odor formation in cutting fluids. For the most part, fluids containing a germicide usually pass this test. The subjects of bacteria attack on soluble cutting fluids, the mechanism of spoilage, odor formation, emulsion failures and disinfection are extremely complex and well beyond the scope of this paper. Several

excellent papers on these subjects have been written by Bennett (1) and by Pivnick and his co-workers (2) (3). This test does illustrate, however, the difference in the ability of soluble cutting fluids to resist deterioration attributed to external contamination. It is recognized that this test procedure is empirical in nature. However, the test does provide a practical means of eliminating some of the fluids possessing poor stability properties which could not be done using conventional emulsion stability tests.

4. *Gumming Test*

The gumming test is also an important qualification for soluble cutting fluids. Again, this is a very simple test designed to determine the deposit or residue formation characteristics of the fluid. This procedure consists of applying a small quantity of 20:1 fluid mixture onto a watch glass and allowing the material to evaporate overnight at 160 F. If the residue is dry or very tacky and not easily re-emulsified, residues can then be expected to form on the machine tools containing the fluids. An oily residue is desired which is easily re-emulsified by the cutting fluid.

Approximately ⅓ of the fluids received for evaluation fail one or more of these tests.

The cutting fluids that pass all of the above screening tests are next subjected to laboratory machinability tests.

MACHINABILITY TESTS

The ability of one cutting fluid to outperform another in certain machining operations has been demonstrated many times (4, 5, 9). The differences between cutting fluids have also been exhibited in numerous laboratory experiments (6, 7, 8). Such information has resulted in a general impression that tool life and/or surface finish in any machining operation may be altered simply by changing from one brand or type of water soluble cutting fluid to another. Machinability tests were designed to investigate these factors since, if such impressions proved to be valid, they would be of considerable importance in the selection of cutting fluids. These tests will also provide basic data for other machinability studies, such as comparisons between tool materials, tool geometry, etc. At first, it was felt that relatively short machining tests might provide sufficient data for evaluation of the cutting fluids. The short tests that were considered were:

1. Comparison of tool forces at operating conditions.
2. Miscellaneous analyses of theoretical chip-tool relationships.
3. Comparison of tool temperature readings at operating conditions by means of the tool-work thermocouple arrangement.
4. Tool life comparison based on accelerated conditions.
5. Constantly increasing cutting speeds to determine the maximum speed reached before tool breakdown occurred.

After numerous trials, it was found that none of the above tests could be directly related to tool life at operating conditions. It was therefore decided that the comparison of cutting fluids would be more meaningful if it were based on typical shop cutting conditions, but with the addition of close controls over the many variables. It was realized at the outset that the optimum choice of cutting fluid may depend on the cutting condition involved. However, since the department has no intention, at least at this time, of using a different cutting fluid for each set of cutting conditions, it was decided to establish a set of conditions for the tests which would be representative of the average cutting condition in the shop. The standard machining tests will therefore provide a comparison of cutting fluids on the basis of general purpose application only. In cases where the optimum cutting fluid for a special application is desired, a separate test, using different cutting conditions, would be necessary.

To facilitate discussion, it will be convenient to consider the machinability testing program in terms of two parts, arbitrary designated as "Evaluation" and "Test."

The machinability program contains a series of evaluations. Each evaluation contains one test fluid and is complete in itself since a common reference fluid is included along with each evaluation. In any one evaluation, all tools to be used are ground at the same time so that the same settings can be used for each tool. Test logs to be used in any one evaluation are selected on the basis of uniform hardness, without too much concern over the actual degree of hardness. During each evaluation the test fluid is alternated with the reference fluid after every tool failure. This is done to equalize the effects of inherent variations in the test logs, changes in test log diameter, as well as other variations that develop with time. Each evaluation consists of a minimum of five tests using the test fluid and five tests using the reference fluid. Each test consists of a separate tool which is run for five minute intervals until the tool fails. The comparison of the test fluid is based on the difference between the average tool life with test fluid and the average tool life with the reference fluid obtained within one evaluation. (Surface finish readings proved to be much more erratic than tool life values so that only tool life is used in the comparisons). Since each evaluation is complete in itself by virtue of the reference fluid, the test fluid can be compared not only to the reference fluid but to other test fluids as well. This has been done (Fig. 2) by placing the average tool life values obtained with the reference fluid in each evaluation along the same reference line and noting the relative differences in average tool life values obtained with each test fluid. Since a considerable amount of scatter exists in the tool life data, it is desirable to know the range within which we could expect additional test data to fall if any of our tests were repeated under identical test conditions. This range has been determined for each evaluation and is illustrated by either the white or shaded blocks. From Fig 2 it is obvious that the same degree of control could not be maintained throughout the series. Fig. 3 shows the average tool life values obtained in each evaluation using reference fluid only. Horizontal

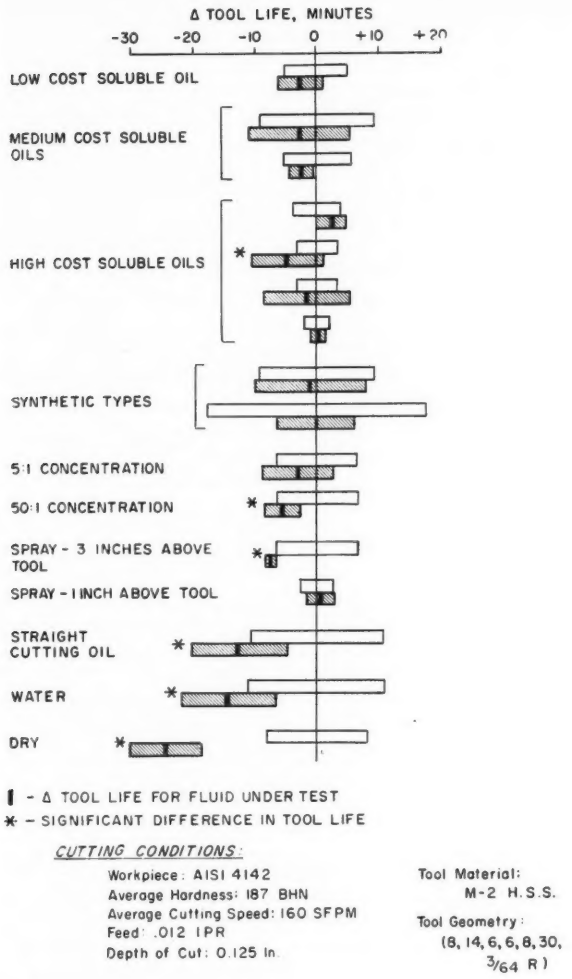
Δ TOOL LIFE, MINUTES
-30 -20 -10 0 +10 +20
LOW COST SOLUBLE OIL
MEDIUM COST SOLUBLE OILS
HIGH COST SOLUBLE OILS
SYNTHETIC TYPES
5:1 CONCENTRATION
50:1 CONCENTRATION
SPRAY - 3 INCHES ABOVE TOOL
SPRAY - 1 INCH ABOVE TOOL
STRAIGHT CUTTING OIL
WATER
DRY
- Δ TOOL LIFE FOR FLUID UNDER TEST
* - SIGNIFICANT DIFFERENCE IN TOOL LIFE
CUTTING CONDITIONS:
Workpiece: AISI 4142
Average Hardness: 187 BHN
Average Cutting Speed: 160 SFPM
Feed: .012 IPR
Depth of Cut: 0.125 In.
Tool Material: M-2 H.S.S.
Tool Geometry: (8, 14, 6, 6, 8, 30, 3/64 R)

Fig. 2. Machinability Test results.

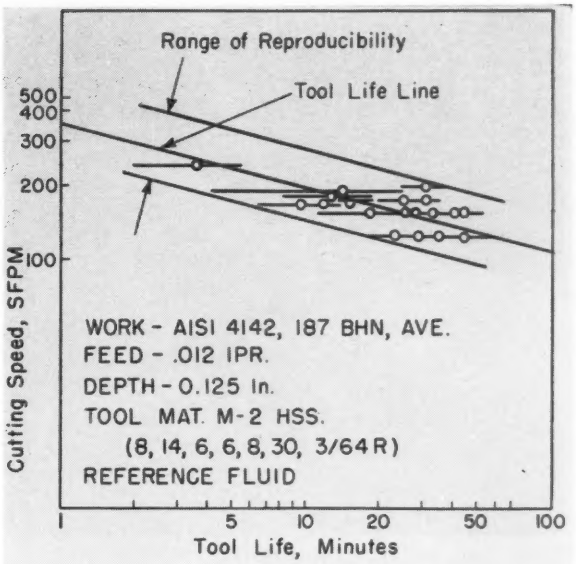

Fig. 3. Tool life data.

lines extending from each point represent confidence limits within an evaluation. The separation of points at any one speed by distances in excess of the confidence limits of any one point indicates that additional variables are encountered from one evaluation to another.

This emphasizes the need for using a reference fluid along with each evaluation. The wide reproducibility range (designated by the light slanted lines) obtained under controlled conditions, provides an indication of the difficulty that would be encountered by shop evaluations where controls are at a minimum.

The test conditions selected are as follows:

Test Logs—Machining in the department is generally confined to low carbon steels, low alloy steels, and stainless steels. The choice of low alloy steel for our tests seems most practical since its machining characteristics are in-between the other two and will therefore represent a general purpose application. Besides, the cost is relatively low compared to stainless steel.

AISI 4142 steel, in the annealed condition, was chosen for the test log material on the basis of uniformity of structure. The material is purchased under standard company specifications and therefore is allowed to vary within certain limits. Closer control over the material would have added considerably to the expense of the tests. The effect of material variation is compensated to some extent by running a reference fluid along with each fluid under test. The average hardness of the bars is 187 Brinell. The size of the test logs is 8 inches in diameter by 2 feet in length.

Cutting Tools—M-2 type high speed steel was chosen for the following reasons:—

1. It is widely used for general purpose work.
2. A cutting fluid has a greater effect on high speed steel tools than on carbides.
3. Since tool life is much shorter with high speed steel tools than with carbides, the tests will be shorter and will require less material.
4. Cutting fluids are more widely used with high speed steel tools than with carbides.

Tool Design—The tool geometry was chosen as typical of high speed turning tools. The tool bit is mounted in a 15° straight tool holder so that the tool could be easily reground by grinding back from the end. The outside of the holder is machined so that it can be positioned accurately. The tool signature is: (8, 14, 6, 6, 8, 30, 3/64R). The tooling setup is shown in Fig. 4.

Feed—The feed 0.012 ipr was chosen since a feed of this magnitude can be generaly found in the shop. It is purposely on the low side of average shop feeds so that the amount of material removed for a given tool life will be low.

Depth—The depth of 0.125 inches was chosen so as to be deep enough to overcome the effects of nose radius (.047 inches) without requiring an unnecessary amount of stock removal.

Fluid Application—The cutting fluid was applied through a ½ inch diameter nozzle located about

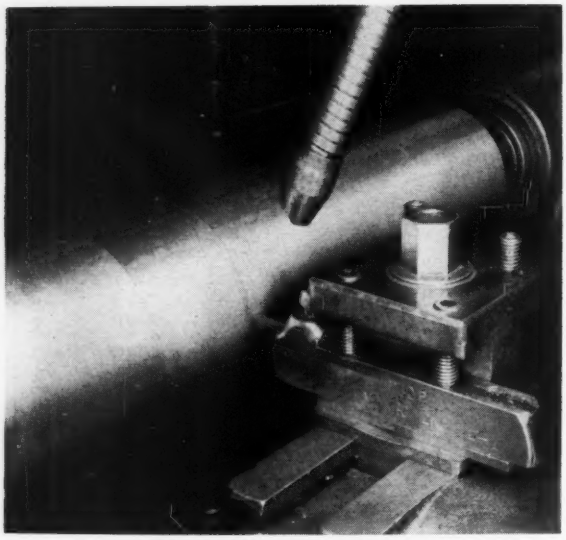

Fig. 4. Tooling set-up for machinability tests.

2 inches above the tool. A flow of approximately 4½ gpm was maintained to insure an adequate supply of cutting fluid (8). The original sump was replaced by a smaller one of special design (Fig. 5) to allow as little as one gallon of fluid to be circulated through the coolant lines. This amount is used only for cleaning and conditioning purposes. A larger auxiliary sump allows a much larger quantity of fluid to be circulated. During the tests, 5 gallons of cutting fluid are circulated in the machine, allowing satisfactory heat transfer.

Test Lathe—A 16-inch engine lathe is used for the tests. A variable speed (20 horsepower ACA) drive motor enables constant surface speed to be maintained for all diameters of the test log. Surface speed is measured on the uncut diameter of the test log by means of a hand tachometer.

Cutting Speed—For test purposes, a tool life between 20 and 30 minutes seemed most desirable. Shorter tests could result in "accelerated" conditions which have little correlation to actual shop practice.

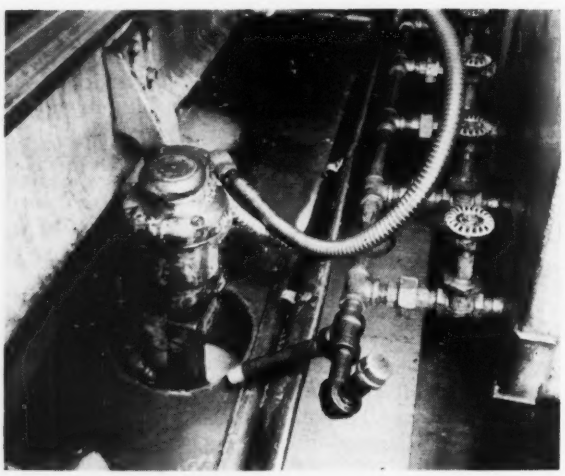

Fig. 5. Coolant sump modifications.

Longer tests not only add to the cost; they tend to increase experimental error. The variations that were allowed to exist in the test log material plus other inherent variations in cutting conditions from test to test made it advisable to change the cutting speed when necessary to maintain tool life close to the desired 20 to 30 minutes. Since a reference fluid is run along with each test fluid and since the comparison is made on a relative basis between the two, neither the change in cutting speed nor the inherent changes in cutting conditions from one evaluation to another should seriously affect the final results. Cutting speeds from 130 to 200 fpm were used, although for any one test fluid only one surface speed was used. Another factor which governed the choice of cutting speed is the type of tool failure desired. This is explained under the next heading.

Tool Life—Tool life measurements are based on total failure of the cutting edge, indicated by:

1. Complete disintegration of the cutting edge signified by an abrupt failure to cut.
2. Disintegration of the cutting edge at some distance behind the nose, signified by a change in the surface finish of the shoulder being formed by the tool.
3. Failure of the nose of the tool, indicated by a taper of .003 inches or more along the diameter of the workpiece after a 5 minute cutting interval.

A typical example of these three types of test failure is shown in Fig. 6.

During the many tests that were run, it was found that any one of the three types of tool failure mentioned above could be generally obtained by making slight adjustments in cutting speed. Although

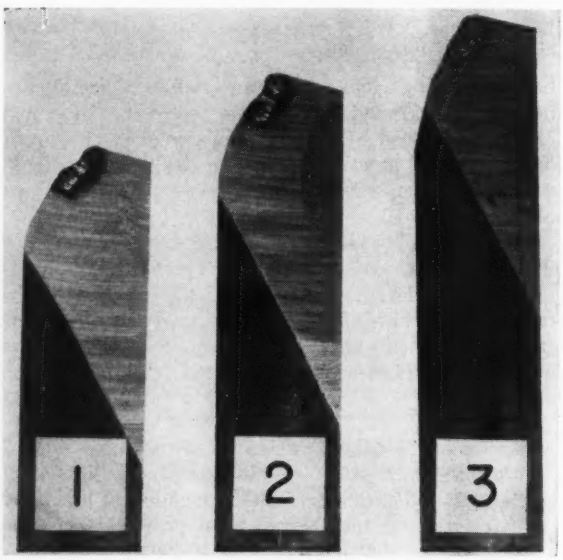

Fig. 6. Types of tool failure encountered in machinability tests.
#1—Complete disintegration of the cutting edge.
#2—Disintegration of the cutting edge at some distance behind the nose.
#3—Failure due to nosewear.

the exact range of speeds for any one type of failure depends on the cutting conditions existing during any one evaluation, it has been found that, in general, in the vicinity of 130 fpm, the third type of failure (nose wear) takes place; in the vicinity of 160 fpm, the second type (edge failure away from the nose) takes place; over 170 fpm the first type (complete edge failure) results. Although the first evaluations contained mixed types of failure, it is believed that better control may be maintained during the evaluation if the speed is adjusted to the point where the same type of failure will occur each time. In later evaluations, the cutting speed was regulated so that the second type (failure away from the nose) was consistently obtained. This type of failure provides a warning when the end point is near by a change in the surface appearance of the shoulder in the test log being generated by the tool. By watching for this change, the cut can be stopped immediately at the point of tool failure. Failure of the first type (complete edge failure) takes place without warning. This indicates premature failure and may not be a true indication of tool life. Failure of the third type (nose wear) is quite gradual with no distinct endpoint. From the work done so far, it does not seem as though the evaluation of cutting fluids would be seriously affected because of the type of tool failure obtained. In the interest of consistency, however, it would appear that the same type of tool failure should be maintained when possible.

Test Procedure—The coolant currently used for general purpose work in the shop has been selected as a reference fluid. Test bars are faced and centered at both ends and a skim cut is taken along the outside diameter to remove the scale before the testing is started. One end of the bar is held in a four-jaw chuck while the other end is held by a live tailstock center. Flats are ground at different positions to enable hardness readings to be taken at each of these positions with a portable Brinell hardness tester. Whenever the diameters of the indentations differ by more than one mm as measured with a Brinell microscope, the bar is set aside and replaced by another which is closer to the desired hardness. The hardness number itself is not considered as important as consistency in hardness for any one evaluation since a reference fluid is included with each test. The test bar that is set aside can usually be included in other evaluations with bars of similar hardness.

The first tool used in an evaluation is allowed to cut with a constant flood of test fluid over the tool. When the tool has cut for five minutes, it is then removed so that the wear pattern can be examined and measured by means of a filar head microscope. These measurements are for record purposes only and are not used for evaluation. The tool is then replaced in the holder and the process is repeated at five minute intervals until tool failure is indicated. At this point, the worn out tool is replaced with another tool. The coolant is pumped back into a special tank. The coolant lines and the entire machine are then thoroughly flushed with a solution of machine cleaner and water. After this is emptied, the lines are charged with a gallon of reference fluid. The pumping system has been modified (Fig. 5) so that when desired, as little as one gallon of fluid may be circulated. The system is then again emptied and the full charge of reference fluid is added for conducting the next part of the test. The same testing procedure is applied to the reference fluid until this second tool fails. This process is repeated and the fluids are alternated until tool life values are obtained for a total of ten tools (five tools for each fluid). A statistical evaluation is then made of the data. The average value of tool life is obtained for both reference and test fluids. The standard deviation is then determined from which the probability range is obtained at 95% confidence limits. Statistical "t"-tests are used to determine whether a statistically significant difference in tool life exists between cutting fluids. Mavericks are eliminated by statistical "R" tests. Although surface finish measurements are also recorded during the tests, this data was not used for final comparison because it was not possible to establish a satisfactory pattern which might be used to compare one fluid against another.

Test Results—Results of such tests are shown in Fig. 2. In this figure, the base line represents the average tool life of the reference fluid. The unshaded bars represent the limits within which this tool life value may be expected to lie, based on 95% confidence limits. The shaded bars represent similar limits for each of the test fluids. The line bisecting each shaded bar represents the difference in the average value of tool life for each test fluid as compared to that obtained with the corresponding reference fluid. All tool life values are averages of a minimum of at least five replications (repeated tests). Examination of the results shown in Fig. 2 indicate that out of nine different soluble fluids tested, only two of these provided average tool life values that were better than the reference fluid. However, the difference in tool life is not great enough to be statistically significant. Fig. 2 indicates that only one soluble fluid is significantly inferior. The other eight fluids tested can be considered acceptable from a tool life standpoint. If a second choice of general purpose fluid is desired, anyone of these eight may be selected. Further selection would be made mainly on the basis of cost, with only a slight consideration being given to the average tool life value. Besides comparing water solubles, plain water (with a slight amount of rust inhibitor) and a straight cutting oil were tested against the reference fluid. These showed a definite inferiority. Dry cutting indicated the lowest tool life, as might have been expected. The results of the latter tests indicate that the machinability tests are sensitive enough to detect significant differences in tool life if they exist. Cutting fluid concentration comparison tests indicate that while increasing the concentration causes no appreciable harm from a tool life standpoint, dilution to as much as a 50:1 ratio reduces tool life to a significant degree.

In a study of atomized spray applications, tests

showed that the spray application may be as effective as a flood application only if the spray nozzle is held close to the tool (about one inch above).

CONCLUSIONS

A cutting fluid evaluation program has been developed which can effectively screen cutting fluids on the basis of physical and machinability characteristics. The tests described have resulted in a periodic savings of many thousands of dollars by eliminating the costly and inadequate shop evaluations. The program has supplied a means for the orderly selection of cutting fluids. The physical tests on soluble fluids supply information as to their effect on machine tool maintenance and help insure against detrimental effects resulting from their use. The machinability tests provide a practical means of cutting fluid comparison on the basis of tool life.

Results of the program may be summarized as follows:

1. The type or brand of cutting fluid should not be expected to cause an appreciable change in tool life in general machining applications.
2. Spray applications can be expected to provide equal tool life to flood applications provided that the spray nozzle is located at least one inch from the cutting edge.
3. Increased concentration of cutting fluid is not expected to improve tool life.
4. Water soluble cutting fluids at a dilution of 20:1 will provide better tool life than straight cutting oil, plain water or a highly diluted soluble oil, for general purpose, single point machining operations.
5. In the selection of cutting fluids for general purpose machining, more emphasis should be placed on the physical properties of the cutting fluids since the possibility of tool life improvement is slim.

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TEST PROCEDURES FOR COMPOUNDS USED AS PRESERVATIVES IN INDUSTRIAL COOLANTS

(Con't. from page 163)

is some evidence that tris (hydroxymethyl) nitromethane also acts *per se*, or through other decomposition products, but the exact nature of these has not been established definitely in the tests made.

SUMMARY

1. Laboratory and plant tests suitable for screening and evaluating antibacterial agents for control of bacteria in coolant emulsions are described.

2. Application of these tests show the efficacy of antibacterial agents as preservatives for cutting oil emulsions, thus minimizing the problems normally encountered.

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1960 Annual Meeting Abstracts

Only those abstracts and photographs available at publication time are included below. A preprint order form appears on page 183.

DEGRADATION OF HIGH TEMPERATURE LUBRICANTS by J. J. Murray and E. P. Scanlan, Chicago Rawhide Mfg. Co., Chicago, Ill., 60AM 1A2

Paper will describe effects of laboratory conditioning of high temperature lubricants of various chemical classes: Diesters, Silicate Esters, Siloxanes, etc. Role of seal component materials in the thermal degradation process will be explored. Variables will be: metals, carbons, ceramics, elastomers. Opposite side of coin will also be viewed, i.e., effect of lubricant and thermal degradation products on seal components.

H. W. Adams

Preprint no. 60AM 3B3

R. W. Belfit Sr.

Preprint no. 60AM 4A3

POSITIVE CONTROL FLAT BACK BEARING, by J. A. Zupez, American Brake Shoe Co., St. Louis, Mo., 60AM 1B1

This paper will deal with a bearing that has a flat back and extending sides to provide closer control of the component parts of the journal box assembly for freight cars. This design only requires a wedge that has a normal radius on the top side and a flat surface on the other side to actively engage the flat back portion of the bearing. No other changes are required. This arrangement allows more positive control particularly between the bearing and the journal so as to maintain a more constant and singular contact pattern between the two.

APPLICATION OF LUBRICATION EXPERIENCE TO THE FREIGHT CAR JOURNAL, by E. Crankshaw, Cleveland Graphite Bronze Co., Cleveland, O., 60AM 1B2

This paper shows how the experience gained from the design and construction of hydrodynamically lubricated engine bearings has been applied to the development of a bearing for railroad freight cars. The new bearing incorporates four features dictated by well-known hydrodynamic principles. These are:

1.) Controlled clearance between bearing and journal.
2.) Abundant supply of oil at the leading edge.
3.) Leading edge relief to permit maximum swept-in oil.
4.) Effective sealing for dirt-free operation.

P. Bennett

Preprint no. 60AM 4C4

S. Brody

Preprint no. 60AM 5A4

HYDRAULIC FILTER REQUIREMENTS FOR INDUSTRIAL SERVO SYSTEMS, by J. A. Farris, Aircraft Porous Media, Inc., Glen Cove, N. Y., 60AM 1C1

This paper defines filtration as applied to industrial electro hydraulic servo control systems. It reviews the critical areas of wet and dry coil servo valves and discusses type and effect of failures on various types of systems.

Filtration requirements are discussed in terms of what is required for a reliable servo control system. Methods of measuring these requirements are reviewed. Degree of filtration, nominal efficiency, absolute cut-off, bubble point, dirt capacity, media migration, built in dirt, abrasion, flow fatigue, channeling, collapse, impulse and element construction are discussed.

The various types of filter media and their characteristics as related to servo systems are discussed. Depth media including paper, felt, fiberglass, diatomaceous earth, and sintered powders; surface media including various types of wire mesh, membrane and magnetic filters are reviewed.

Recommendations are made for proper servo system filtration media.

Various filter housing limitations and features are described: specifically, relief valves, differential pressure indicators and automatic shut-off. Modular mounting of filter elements in servo packages is discussed and illustrated.

Filters presently in use to protect servo systems are illustrated and the report concludes with a recommended specification for filter elements for the protection of electro hydraulic servo control systems.

TRAINING THE USER OF HYDRAULIC EQUIPMENT, by F. L. Mackin, General Motors Inst., Flint, Mich., 60AM 1C2

This paper covers the numerous applications of fluid power throughout our industry, and then proves that there is a definite need for training in this field.
The training should start in our plants with such men as the maintenance men, machine builders, setup men, operators and electricians.
The second phase of training should be in the design field with machine designers, tool designers, process men, electrical engineers and electrical designers.
In order to assure an adequate supply of trained men in the future, the training of apprentices is discussed.
The responsibility of this training should be divided between industry and our engineering and technical schools.
The need for laboratories is emphasized as much as just theory alone will not produce a qualified workman. The methods in training are discussed with the relation between laboratory, and classroom and discussion.
An attempt is made to look into the future and find the solution to some of our problems such as the increased use of electro-hydraulic servo mechanisms.

S. F. Calhoun

Preprint no. 60AM 3B2

B. C. Carter

Preprint no. 60AM 1C3

PRECISE DUPLICATION BY HYDRAULIC TRACING, by B. W. Carter and H. Horlacher, Cincinnati Milling Machine Co., Cincinnati, O., 60AM 1C3

Experience over the years has taught the men connected with hydraulic tracing how to make valves responsive to the minutest signals. To be successful in precise duplication several factors have to be accomplished. The valves have to be made to high quality and construction; the hydraulic system has to be properly arranged; the oil must be filtered and kept within certain temperature ranges, also the machine structure and tracer suspension is very important.
Contour tracing is performed often simultaneously on multiple axes and on some application under automatic control.

DISPOSAL AND CONSERVATION OF LUBRICATING OIL BY RE-REFINING, by A. B. Two, Motor Oils Refining Co., Lyons, Ill., 60AM 2A1

This paper will show that it is economically feasible and also practical from a technical standpoint to re-refine lubricating oil. Further, it shows that re-refining is a major means of conservation of our most important natural resource, crude oil.
Further, this paper will outline how re-refining is a solution to the problem of lubricating oil disposal.

CENTRIFUGAL PURIFICATION OF LUBRICATING OIL, by C. M. Ambler, Sharples Corp., Philadelphia, Pa., 60AM 2A2

The paper will describe and discuss the use of centrifuges for the continuous and batch purification of lubricating oil with particular reference to the results obtained on steel mill and marine diesel applications.

PURIFICATION OF MISSILE HYDRAULIC OIL, by E. G. Bahret, The De Laval Separator Co., Poughkeepsie, N. Y., 60AM 2A3

This paper would cover the function of hydraulic oils in missiles, the contaminants which accumulate in the oil, the rate of contamination, types, and the effect of. The paper would cover the purification of these oils, the method, capacity, effectiveness, analytical methods used and the general economic advantages in purifying such oils.

USE OF ALUMINUM IN LUBRICATION SYSTEMS—DESIGN AND SPECIFICATIONS, by E. McDole, Kaiser Alum. & Chem. Corp., Ravenswood, W. Va., 60AM 2B1

The purposes of this paper are (1) to present information necessary for design of lubrication systems, and (2) to show where aluminum might be used to great advantage to the people who are most interested in its use—the production and maintenance personnel.
Designs of systems are usually made by engineers; either lubrication, mechanical or chemical. Some designs are provided by maintenance department personnel and some by salesmen or sales engineers. It is believed that satisfactory designs can be provided quickly when the designer has a satisfactory set of specifications. Of course, he must also know where such specifications are applicable.
Aluminum alloy piping and fittings, etc., can be used advantageously in many systems. The advantages of its use are given in the paper along with comparative costs. Limitations of applicability are also shown.

E. Crankshaw

Preprint no. 60AM 1B2

J. A. Farris

Preprint no. 60AM 1C1

LUBRICATION REQUIREMENTS OF THE ROTARY REGENERATIVE AIR PREHEATER, by J. Waitkus, Air Preheater Corp., Wellsville, N. Y., 60AM 2B2

This paper will introduce a description of the rotary regenerative air preheater with special emphasis placed on those components of the equipment requiring lubrication considerations.

A description of the general conditions of application of the equipment should serve to support the special considerations required.

THE LUBRICATION REQUIREMENTS OF NUCLEAR POWERED SURFACE VESSELS-DESIGN CONSIDERATIONS, by E. H. Okrent, Esso Research & Engrng Co., Linden, N. J., 60AM 2B3

This paper considers the effect of nuclear surface vessel design on the functional requirements of lubricants. Toward this end, the critical design features of potential nuclear surface propulsion systems have been reviewed to determine the physical requirements imposed on the lubricant by the total environment, radiation being only one of the many factors to be considered. This review has indicated that the lubrication problems of nuclear propelled ships are similar to those of their conventional fossil-fueled counterparts. Radiation stress, the main new environmental feature, is a consideration only in those components which are associated with the nuclear heat source (control rods, etc.), and then it is generally not a controlling consideration. The lubricants for the propulsion gear and its auxiliary systems present no new lubrication problems. However, leakage and primary coolant contamination requirements often take precedence in the selection of the lubricant or lubrication system.

PLASTIC YIELDING AND VIBRATION OF ROLLING ELEMENT BEARINGS, by T. Tallian, O. G. Gustafsson and H. O. Walp, SKF Industries, Inc., Philadelphia, Pa., 60AM 2C1

A high degree of resistance to plastic deformation at the contacts between rolling bodies and rings is required in bearings used for equipment that must be quiet running. It is shown that, within practical bearing design limits this resistance is primarily a function of material structure variables that affect the elastic limit.

Rockwell or Diamond Pyramid hardness is a primary variable, but in itself, an inadequate measure of this resistance. A test method is described giving good correlation with conditions causing plastic deformation of bearings in applications. Improvements in plastic deformation resistance are shown to be obtainable by appropriate heat treatment. The effects of residual stress, surface conditions and contact configuration are discussed.

L. Floberg

Preprint no. 60AM 5A1

E. O. Forster

Preprint no. 60AM 5B3

AN INVESTIGATION OF OILS FOR USE IN HELICOPTER OSCILLATING BEARINGS, by L. A. Donnelly, Sikorsky Aircraft, Stratford, Conn., 60AM 2C2

The Sikorsky Aircraft Friction Oxidation Tester causes tapered roller bearings to fail with two distinct and independent types of failure, either alone or in combination with each other. One type of failure is described as fatigue pitting, and the other as surface damage in the form of fretting corrosion and abrasion. The tester strikes very distinct differences among lubricants depending on how well they inhibit either or both of these types of bearing failure. The machine will also repeat consistently the type of failure and time to failure for any given oil.

The conclusions reached are that this machine provides an accurate and reliable means of testing lubricants according to their ability to inhibit fatigue pitting and surface damage; and that correlation exists or can exist between tester data on oils and their actual behavior in oscillating bearings of a helicopter rotor head.

A STUDY OF THE TORQUE CHARACTERISTICS OF GREASE PACKED R-2 AND R-3 BEARINGS, by J. C. Lawrence, SKF Industries, Inc., Philadelphia, Pa., 60AM 2C3

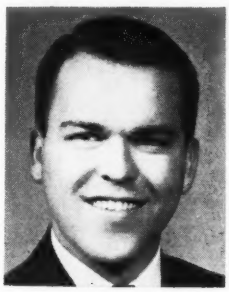
The purpose of this program was to determine the effect of grease type, grease amount, thrust load, and

separator type on the torque characteristics of shielded R-2 and R-3 size ball bearings. Torque determinations were made at 1 to 2 rpm and at 15,000 rpm. All data was taken at room ambient temperature. Categorically, the results were:

1. Grease No. 1 (a diester oil thickened with a lithium soap meeting MIL-G-3278) consistently yielded the lowest torque for all bearing and load configurations tested. Grease No. 2 (a synthetic oil lithium soap thickened grease conforming to MIL-G-7118) displayed the second lowest torque reading and grease No. 3 (a silicone oil, aryl substituted urea thickened grease) resulted in the highest torque of the three greases tested.
2. One piece cage configurations consistently yielded lower torque for the same load and grease type than did the two piece cages except in the case of R-3 bearings with grease No. 2, in which case two piece cages yielded slightly lower torque at the higher grease amounts than did the one piece cages.
3. The torque level due to 1 and 3 lb. thrust loads for all grease and cage configurations are given in detail in the body of the paper. In general, the torque level due to the 3 lb. thrust load was higher than that resulting from the 1 lb. thrust load.

E. J. Gesdorf

Preprint no. 60AM 5C3



W. L. Haviland

Preprint no. 60AM 6A1

PERFORMANCE OF EP GEAR LUBRICANTS IN THE REAR AXLES OF AN OVER-THE-ROAD TRUCK FLEET, by W. C. Brandow, Lubrizol Corp., Cleveland, Ohio, 60AM 3A3

The proposed paper will present a summary of results obtained by testing four different lubricants—three of MIL-L-2105 quality, one of MIL-L-002105A (Ord.) quality—in the rear axles of 25 trucks of the same make operated by a commercial carrier. One of the major truck axle manufacturers had recommended this fleet for test purposes because of operational difficulties in the rear axles. Operation of the vehicles was according to commercial carrier practice and, therefore, represents a typical field service condition. Controls were applied only to the selection and supply of lubricant, preparation of test axles, specification of drain interval and disassembly and inspection of axles after test.

Results shall show the effect of the four lubricants on:

(1) Overall axle life.
(2) Condition of ring and pinion contact surfaces regarding scoring, rippling, ridging or other defects.
(3) Formation of deposits, rust or corrosion.
(4) Bulk oil temperature under normal service conditions.

As far as is possible, the axle service difficulties occurring in this fleet will be outlined and analyzed as to cause and possible corrective measures.

H. Horlacher

Preprint no. 60AM 1C3

R. L. Lenning

Preprint no. 60AM 6B1

ANTIWEAR AND EXTREME PRESSURE ADDITIVES FOR GREASES, by S. F. Calhoun, Rock Island Arsenal, Rock Island, Ill., 60AM 3B2

This paper gives the results of a study made on antiwear and E. P. additives in Lithium base greases. Several additives of various known compositions were evaluated at various concentrations. The machines used in the evaluation include the Shell Four-ball Wear and E. P. machines, the Falex tester and the Timken machine. The composition, manufacturing procedure, and consistencies of the greases were kept as uniform as possible so that the results are indicative of additive efficiency.

Conclusions on additive effectiveness are drawn from the results obtained.

HIGH TEMPERATURE GAS TURBINE LUBRICANTS, by H. W. Adams, WADC, Dayton, Ohio, 60AM 3B3

Paper is concerned with research and development effort in the development of a high temperature aircraft gas turbine lubricant formulation. Emphasis is placed upon derivation of a suitable anti-oxidant package effective in preventing oxidative deterioration and the importance of such to efficient lubrication.

SURFACE ACTIVE AGENTS AS EP CONDITIONERS, by E. S. Reynolds, Socony Mobil Oil Co., New York, N. Y., 60AM 3B4

This paper will discuss, from a lubrication engineer's standpoint, the basic extreme pressure elements and

combinations of elements and their general surface activity and suitable applications.

THE PERFORMANCE OF HEAVILY LOADED OSCILLATING ROLLER BEARINGS OPERATING FROM 300 F TO 600 F, by W. A. Glaeser, Battelle Memorial Inst., Columbus, Ohio, 60AM 3C2

Over 1000 roller bearings have been evaluated at elevated temperatures as oscillating bearings and load-life characteristics determined through statistical analysis of failure data. Operating temperatures of 300 F, 450 F, and 600 F were investigated. Bearing materials investigated included AISI 52100 steel, M-2 tool steel and 440-C stainless steel. Grease lubrication was used. The bearing load range included 250,000 psi to 500,000 psi maximum Hertz stress. AISI 52100 steel proved satisfactory for temperatures to 450 F. Tool steel (M-2) and 440-C stainless steel proved satisfactory for temperatures to 600 F. Although failure modes were predominantly by plastic deformation, wear and oxidation, failure distribution frequencies fit the Weibull distribution commonly used in bearing fatigue studies. Data scatter was less than that expected for continuously rotating ball bearings.

E. H. Loeser

Preprint no. 60AM 4C2

F. L. Mackin

Preprint no. 60AM 1C2

OPERATING CHARACTERISTICS OF 75 MILLIMETER BORE BALL BEARINGS AT MINIMUM OIL FLOW RATES OVER A TEMPERATURE RANGE TO 500°F, by F. T. Schuller and W. J. Anderson, NASA, Cleveland, Ohio, 60AM 3C3

Experiments were performed to determine the actual minimum oil flow requirements of deep groove ball bearings at DN values of $6.0X10^5$ to $12X10^5$, thrust loads of 1000 and 3000 pounds and bearing temperatures to 500°F with air-oil mist lubrication. With a synthetic diester oil, required minimum flows (on the order of 10^{-5} to 10^{-2} lb/min) increased with increasing DN, load, and temperature to 400°F. At 500°F varnish deposits formed which apparently aided lubrication and reduced the flow required below that at 400°F. Bearing temperature and torque generally decreased with decreasing oil flows down to the minimum-oil-flow conditions. As an example of the very low oil flows required, it was possible to run size 215 bearings satisfactorily at 12,000 rpm ($9.0X10^5$DN), 400°F, and a 1000 pound thrust load with flows as low as 0.003 pounds per minute.

BRASS ROLLING EMULSIONS, by R. W. Belfit, Sr. and N. E. Shirk, Scovill Mfg. Company, Waterbury, Conn., 60AM 4A3

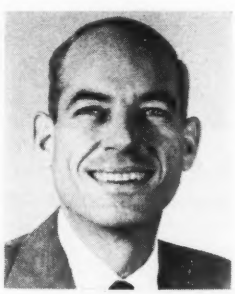
Emulsions used as brass rolling lubricants provide better cooling, adequate reductions, higher speeds and cleaner, brighter strip than most mineral oil or mineral oil-water coolant combinations. The paper describes several oil-in-water emulsions which have met the user's requirements in a wide variety of brass rolling mill equipment.

Laboratory tests guided the supplier in the development of an emulsion with less tendency to stain brass. Prevention of water stain is a persistent problem in producing high quality strip. Viscosity of the mineral oil used in the emulsion is critical on 4-High mill operations. Higher viscosities are necessary on intermediate or breakdown gauges and lighter viscosities on finish gauges.

Material and maintenance costs are comparable to mineral oil-water coolant systems. Operating personnel prefer to use emulsions for simplicity of application, easier stripping from the metal and easier "sticking" or starting of bars.

E. E. McDole

Preprint no. 60AM 2B1



V. H. McNeilly

Preprint no. 60AM 5A2

TEFLON INSERT COMPRESSION RINGS IN RADIAL GAS ENGINES, by D. W. Sawyer, ALCOA Res. Labs., New Kensington, Pa., and D. A. Paull, Sealed Power Corp., Muskegon, Mich., 60AM 4C1

A cast iron compression ring containing a Teflon-glass laminate insert has been developed. Full scale engine tests employing both eleven and twelve cylinder radial gas engines have been carried out. Test results indicate that these engines will operate successfully when equipped with these rings and the upper cylinder forced-feed lubricators completely shut off, resulting in considerable savings in oil and maintenance man-hours.

BENCH TEST OF CAM AND TAPPET WEAR IN ADDITIVE OILS, by E. H. Loeser, Chrysler Corp., Detroit, Mich., 60AM 4C2

The paper concerns the wear results obtained in the Chrysler Lubricant Tester with the five oils used in the CRC field survey of camshaft and valve tappet wear. These results are compared with available field car and engine dynamometer data. The measured amounts of wear differed among the three methods. The bench test, however, is a rapid, relatively inexpensive method of wear determination, since it clearly showed differences in the valve train wear among the five CRC oils and correlated with the other test methods. Oil additives, such as barium phenate, sulfurized olefin and zinc dialkyl dithiophosphate affected the wear of hardenable cast iron cams and tappets. Statistical analysis of the bench test runs showed that variations in wear results may occur; they are more easily interpreted and controlled than those occurring in dynamometer and field tests.

MEASURING THE OIL FILM THICKNESS IN ENGINE BEARINGS, by W. D. Sims, Shell Development Company, Emeryville, Cal., 60AM 4C3

Much theoretical work has been recorded regarding the oil film or "wedge" existing in rotating plain bearings. All such work which has come to our attention, however, has, perforce, neglected the cumulative effects of cyclic loading, crankshaft flexure in both transverse and torsional references and the engine structural vagaries found in actual operating engines. In an effort to bridge this gap in the art, an experiment has been conducted whereby the thickness of the oil film on the loaded side of the crankshaft bearing of an otherwise standard automotive engine was measured. Observations were made over a wide power range with oils of three widely differing viscosity levels.

The observations indicated that the oil film thickness between the crankshaft and the loaded side of the bearing varied from 0.002" at light load to approximately 0.0005" at full load and was essentially unaffected by the different viscosity oils.

The instrumentation employed in the measurements of bearing oil film thickness (clearance on the loaded side of bearing) in an operating V-8 automotive engine is described and the significance of the measurements obtained is discussed.

BOUNDARY CONDITIONS OF CAVITATION REGIONS IN JOURNAL BEARINGS, by Leif Floberg, Chalmers Univ. of Tech., Gothenburg, Sweden, 60AM 5A1

The paper treats the behaviour of the oil in a cavitation region. Boundary conditions of the pressure distribution at the inlet and at the outlet border of such a region are given. Calculation of the power loss in a cavitated zone is demonstrated.

DESIGN AND USE OF PNEUMOSTATIC BEARINGS, by V. H. McNeilly, E. I. du Pont de Nemours & Co., Wilmington, Del., 60AM 5A2

Intended to be primarily an informative type of paper on pneumostatic bearings (hydrostatic air bearings) covering some practical aspects of their use, simplified design procedures, possible arrangements and economic factors.

E. H. Okrent

Preprint no. 60AM 2B3

D. A. Paull

Preprint no. 60AM 4C1

HIGH TEMPERATURE MOLTEN SALT LUBRICATED HYDRODYNAMIC JOURNAL BEARINGS, by P. G. Smith, Oak Ridge Nat'l. Lab., Oak Ridge, Tenn., 60AM 5A3

This investigation is concerned with the development of hydrodynamic journal bearings lubricated with molten salt fuel No. 130 (62 LiF, 37BeF_2, 1 UF_4 Mole %) at temperatures of 1200-1500°F. This work was performed to develop bearings specifically for molten salt reactor pumps; however, it may be of value elsewhere in the field of high temperature lubrication.

This paper will cover the application of published bearing design theory to molten salt bearing design, selection and design of the test apparatus, selection of bearing materials, bearing tests, and application of bearing to a vertical shaft centrifugal pump. Approximately 3000 hours of successful test operation has been logged on the bearing tester wherein experimental investigations were made on performance, start-stop ability, and bearing material thermal stability. Testing of a vertical centrifugal pump containing a molten salt lubricated bearing will begin in the very near future, the preliminary results of which will also be reported in the paper.

SOLUTION OF REYNOLDS' EQUATION FOR A PLANE SLIDER BEARING OF A FINITE WIDTH WITH AN ISOTHERMAL GAS FLOW, by S. Brody, IBM Corp., Oswego, N. Y., 60AM 5A4

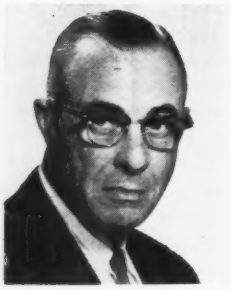
The designer of an air pad requires accurate information on the load, center of pressure, and friction fac-

tors. A search of the literature showed that there is a need for more extensive solutions of Reynolds' equation, in the form of numerical values that are accessible and useful to the designer. This paper presents the numerical values, obtained by using a 704 computer, of the load, center of pressure, and friction factors for a plane inclined slider bearing with a gas film. These values are presented in tabular form for various slenderness ratios of pad versus film thickness ratios. The resulting tables offer a simplified approach to the design of slider bearings and are applicable whenever certain conditions (laminar viscous flow, constant viscosity, etc.) are also met. A typical problem illustrating the use of the information contained in the tables is included.

LUBRICATION PROBLEMS ENCOUNTERED IN SPACE VEHICLES, by M. M. Freundlich, Airborne Instr. Lab., Melville, N. Y., 60AM 5B1

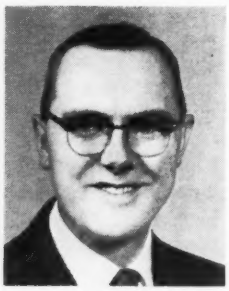
Ordinary lubricants have such a high vapor pressure that they evaporate under conditions of space, where a vacuum of 10^{-8} mm Hg or lower exists. For long unattended operations these lubricants are not useable unless the motors operate in hermetically sealed boxes. For intermediate operating periods of several 100 hours to possibly 1000 hours special lubricants have to be selected.

We have tested at a temperature of 110°C and a high vacuum of 10^{-6} mm Hg 40 different oils and 20 greases and have determined their evaporation rates under these conditions. The lubricants showing the lowest evaporation rates are presently undergoing life tests in small aircraft type motors at 4000 r.p.m. to determine their lubrication qualities under space conditions.



E. S. Reynolds

Preprint no. 60AM 3B4



J. J. Rodgers

Preprint no. 60AM 6A1

THE EFFECT OF ENVIRONMENTAL CONDITIONS, INCLUDING RADIATION, ON THE PERFORMANCE OF GREASES by P. J. Aquis and A. L. Morris, Esso Research Ltd., Abingdon, Berkshire, England, 60AM 5B2

Many environmental factors taken together affect the choice of a grease for a particular application. Such factors as temperature, radiation dosage, ambient atmosphere (carbon dioxide, air, water vapour) and maintenance schedule will determine the performance of a grease under the mechanical conditions imposed on it. The implications of these on the choice of greases for nuclear power reactors and for aviation use is discussed.

RELAXATION PHENOMENA IN LUBRICATION, by E. O. Forster, Esso Research and Engrng., Linden, N. J., 60AM 5B3

The flow behavior of lubricants is an extremely important factor influencing their lubricating ability and is commonly described by the conventional viscosities measurements. These conventional measurements are, however, limited by the assumption that the lubricant responds instantaneously to a stress by starting to flow. Actually, lubricants do not behave like this and have to be characterized not only by a viscosity but also by an elastic modulus. The time dependence of the elastic and viscous properties are discussed on the basis of experimental data and results published in the literature. It is shown that the elastic properties of straight mineral oils become significant if stresses last for periods shorter than 10^{-9} to 10^{-10} seconds. In the case of polymer-modified oils, these properties become significant already at times ranging from 10^{-5} to 10^{-7} seconds and greases show elastic behavior already in the range of 10 to 10^{-2} seconds. The practical significance of these viscoelastic properties in the lubrication of gears and bearings is analyzed. The results of this investigation suggest that the elastic effects have to be taken into consideration in predicting the performance of lubricants in machine elements.

H. G. Rylander

Preprint no. 60AM 6A3

D. W. Sawyer

Preprint no. 60AM 4C1

CENTRALIZED RE-CIRCULATING COOLANT SYSTEMS FOR COLD ROLLING OPERATION IN THE STEEL AND ALUMINUM INDUSTRIES, by J. Philip Wettach, Dravo Corporation, Pittsburgh, Pa., 60AM 5C1

This paper will outline some of the basic types of coolant systems being employed in the industry today, pointing out the different design involved for processing metals such as aluminum, brass, and various types of steel such as silicon, stainless, etc. It is estimated that the production of aluminum foil per year would reach 300 million pounds by the end of 1960. The stepped up activity in this and other fields, along with the desire to roll faster and with improved surface finish has placed an added responsibility on the central coolant systems.

In recent years various new developments, especially in the field of filtration and clarification of coolants have been satisfactorily employed. These will be discussed along with their various advantages.

LUBRICATION IN THE TEXTILE INDUSTRY, by T. M. Murphy, Alemite Div., Stewart Warner Corp., Chicago, Ill., 60AM 5C2

This paper will report to the Industry on the advance made in applying extremely small quantities of lubricant to the rings and travelers of spinning and twisting frames used in the Textile Industry.

The problem involves a method of conveying the lubricant to the surface of hardened steel rings and the ability to measure small quantities of lubricant approximating .0001 cu. in. quantities.

The solution of this lubrication problem has resulted in increased speeds and production on some machines without mechanical modification. On others the solution of the lubrication problem justified the mechanical modification of the machines to the point where they could approximately double speed in production.

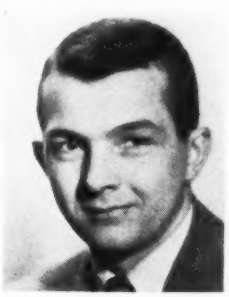
Many other advantages of centralized lubrication are also reported.

CENTRALIZED LUBRICATION IN THE STEEL INDUSTRY, by E. J. Gesdorf, Farval Corp., Cleveland, Ohio, 60AM 5C3

This paper will cover thirty-five years of steel mill operation with centralized lubrication equipment. A short review of the history and evolution of centralized lubrication equipment in the steel industry will be given. This will be followed by a discussion on how a user can get the most out of this type of equipment. Some emphasis will be placed on benefits derived through the use of this equipment. The paper will conclude with recent developments in centralized lubrication equipment and a forecast of things to look forward to.

F. T. Schuller

Preprint no. 60AM 3C3



N. E. Shirk

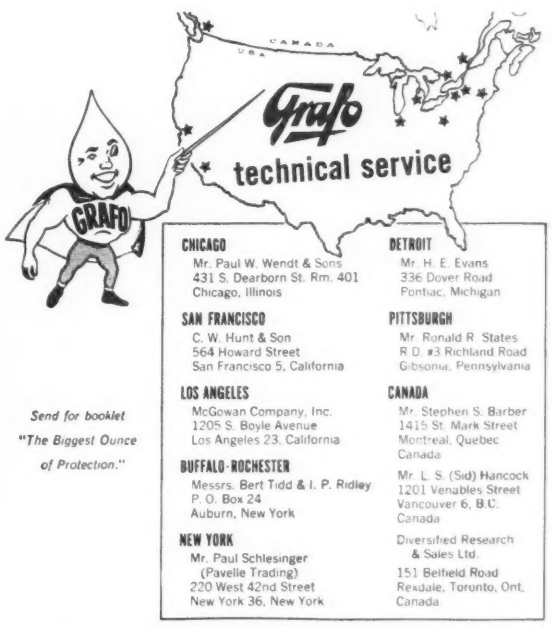
Preprint no. 60AM 4A3

FRICTION CHARACTERISTICS OF AUTOMATIC TRANSMISSION FLUIDS AS RELATED TO TRANSMISSION OPERATION, by M. L. Haviland and J. J. Rodgers, General Motors Research Labs., Warren, Mich., 60AM 6A1

Shift performance in automatic transmissions has been found to be related to the frictional qualities of transmission fluids. This relationship has been studied in two types of apparatus—one a full-scale transmission setup and the other a bench apparatus. The transmission setup included an Oldsmobile engine, a 1958 Hydra-Matic transmission, and a dynamometer. The bench apparatus simulated clutch plate sliding that occurs during shifting operations.

In full scale transmissions, fluids were evaluated with respect to shift performance, severity of stick-slip, and oxidation resistance. Shift performance and severity of stick-slip were determined by analysis of recorded variables such as output shaft torque, engine speed, and transmission pressures as functions of time. By measuring fluid acidity periodically during each investigation, an interrelationship between fluid oxidation resistance and stick-slip was found. Since an increase in fluid acidity is normally attributed to oxidation, fluid oxidation was essentially eliminated by operating the transmission in an inert atmosphere. Under this condition the occurrence of stick slip and squawk was accelerated.

In the bench apparatus, measurements of friction as a function of sliding speed were made with load and fluid temperature as parameters. These measurements were made not only with new fluids but also with fluids conditioned by transmission use. A correlation was found between fluid frictional characteristics in a transmission and the frictional measurements in the bench apparatus.



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EVALUATION OF A FIRE RESISTANT FLUID IN A CIRCULATING OIL SYSTEM, by E. J. Tullos, Union Carbide Nuclear Co., Paducah, Ky., 60AM 6A2

An operational investigation of a phosphate ester base fire resistant type fluid was conducted to evaluate (1) the fluid properties for lubrication of journal type bearings by means of a circulating oil system and (2) the replacement of a petroleum base oil in an operating system by direct addition of the fire resistant fluid without an equipment shutdown to drain and clean the oil system. Preliminary laboratory tests were made to determine the solubility of the oil in the fluid so that the feasibility of centrifugal separation of a mixture of the two materials could be established.

The operational test was conducted by directly adding the phosphate ester fluid to the petroleum oil in a circulating oil system used to lubricate the bearings of an axial flow gas compressor, and then separating the two lubricants by centrifuging. The centrifugation reduced the petroleum oil content in the circulating system to less than 5% while 12% of the phosphate ester fluid added was dissolved in the petroleum oil and withdrawn from the system. The lubricating quality of the phosphate ester fluid was evaluated by noting the constancy of the circulating system temperatures and pressures and by comparison of the bearing inserts with those from similar equipment, operated in the processing plant and lubricated with the petroleum oil.

W. D. Sims

Preprint no. 60AM 4C3

P. G. Smith

Preprint no. 60AM 5A3

VISCOSITY, GAS ABSORPTION AND DENSITY OF SEVERAL MULTIPHASE LUBRICANTS, by L. R. Dickerson, H. G. Rylander and G. W. Crawford, University of Texas, Austin, Texas, 60AM 6A3

The viscosity, solubility, and density of several two and three phase lubricants were determined experimentally in a temperature range of 80 F to 200 F and a pressure range of 50 psia. tp 600 psia. Equations were found which would accurately describe the viscosity and density of these lubricants at other temperatures and pressures. Micro-size particles of molybdenum disulphide were suspended in petroleum-base oil with absorbed quantities of various gases. Lubricants of 4 weight per cent gas-oil mixtures had viscosity decreases of up to 60 per cent relative to the oil viscosity, while the oil density remained virtually unchanged.

STATISTICAL ANALYSIS OF LUBRICANT TESTS, by J. J. Geissler, U. S. Steel App. Res., Monroeville, Pa., 60 AM 6A4

Paper will present the statistical methods used in the analysis of lubricant tests in order to determine the repeatability and reproducibility of the test.

THE TRANSITION FROM BOUNDARY TO MIXED FRICTION ON FLAT SLIDING BEARINGS, by R. L. Lenning, Cincinnati Milling Machine Co., Cincinnati, Ohio, 60AM 6B1

An investigation has been carried out to determine how various factors influence the surface velocity at which the transition from boundary to mixed friction occurs in flat sliding bearings. The paper deals mainly with experimental studies and touches lightly upon the application of theory. The results of this research, although conclusive only in general terms, can be used as design considerations. These results give promise of usefulness as additional original research information in this area and set the stage for further exploratory work which will in turn increase the store of knowledge in both the practical and the theoretical aspects of boundary and mixed friction.

E. J. Tullos

Preprint no. 60AM 6A2

A. B. Two

Preprint no. 60AM 2A1

PROGRESS IN THE IDENTIFICATION AND STANDARDIZATION OF LUBRICANTS FOR MACHINE TOOLS, by M. W. Papp, Warner & Swasey Co., Cleveland, Ohio, 60AM 6B2

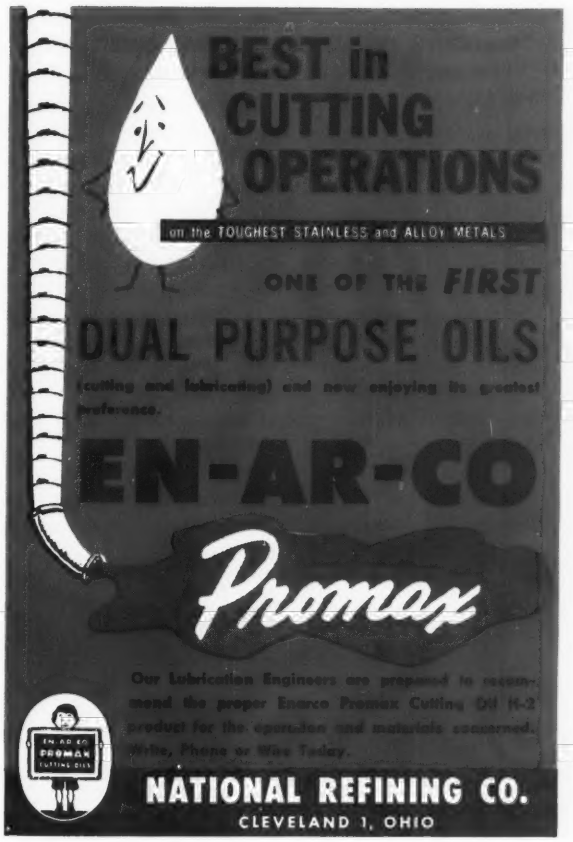
For many years, most machine tool builders have specified brand name lubricants for use on their products. This long established custom, however, has led to increasingly complex problems of marketing, inventory, maintenance and excessive costs for the machine builders' customers, as well as themselves. A concerted effort to find satisfactory solutions to these problems through standardization has been carried on by the Machine Tool Industry Council of ASLE since its inception in 1957. This paper will illuminate the lubricant problems confronting the machine tool builders, and the need for and universal advantages of standards, specifications, or some other suitable methods of describing recommended lubricants. The work of the Machine Tool Industry Council in these parameters will be described and (if available by that time) their final proposed solutions to the problem will be presented.

THE EFFECT OF VARIOUS CUTTING FLUID TYPES ON RESIDUAL STRESS WHEN GRINDING HIGH TEMPERATURE ALLOYS, by D. H. Stewart and H. R. Soderstrom, General Electric Co., Cincinnati, Ohio, 60AM 6B3

Residual stresses are inherent in practically all operations where metal is shaped. The degree to which these stresses are present will determine whether the resulting part is damaged by either measurable distortion or stresses which result in premature failure. The use of high temperature alloys has increased the need for low stress machining operations because of the inherent susceptability of these alloys to induced residual stress.

Stress produced during the grinding of high temperature alloys has been evaluated by test methods. The method uses the resulting deflection of ground test specimens as the basis for evaluation. Results are measurable in terms of both stress level (pounds/square inch) and depth of stress penetration.

Grinding fluids are among the variables which have a substantial effect on stresses produced. This paper presents the effects of grinding fluids as to stress for both the basic types, oil vs. water and for the various chemical analyses among oils.



FRICTION AND WEAR OF REFRACTORY COMPOUNDS UP TO 2000°F by K. P. Zeman and L. F. Coffin, Jr., General Electric Research Lab., Schenectady, N. Y., 60AM 6C1

In this study the sliding characteristics of the borides, carbides, nitrides and silicides and oxides of several metals were investigated at temperatures up to 2000°F. Tests were of the crossed-cylinder type with friction and wear effects measured under repetitive sliding conditions.

For this class of material both the friction coefficient and wear resistance were found to vary over wide ranges depending on the particular couple chosen. When no solid solubility was known or predicted the coefficient was usually less than 0.60 and the wear scar small. If abrasion, caused by mechanical fracture of the materials at the interface (sometimes due to poor finish or inferior material), occurred these results were much poorer. Reaction with the environment, principally oxidation, influenced the friction and wear processes by causing them to be related to the oxide characteristics. For example, formation of titanium-oxide leads to a decrease in friction and wear above 1100 to 1200°F—the softening point of the oxide—and boric oxide, obtained from the oxidation of the borides and B_4C, can provide viscous liquid lubrication above 1400°F.

FUNDAMENTAL PROCESSES IN LUBRICATING METAL SURFACES AT 100°F TO 1700°F, by E. N. Klemgard, Washington State University, Pullman, Wash., 60AM 6C2

An experimental study has been made of a few important fundamental processes occurring in nickel alloy-solid lubricant systems operating in air, within the 100°F to 1700°F range. The conclusions drawn are based on experimental evidence from over 150 evaluations of friction, wear, and surface damage involving multi-component solid lubricants containing graphite, boron oxide, silver chloride, silver fluoride, metal phthalocyanine, molybdenum disulfide, lead oxide, and sodium silicate.

The controlling processes are discussed under three major headings: (a) Physical and Chemical Changes in the Surface Layers, (b) Changes in the Metal Substrates, and (c) Changes in Bulk Lubricant Film. In addition to the basic processes prevailing in boundary lubrication with conventional lubricants at temperatures below 200°F, the high temperature ranges with solid lubricants, include processes covering variable yield and shear strength, hardness and diffusion of the substrates. Chemical reactions (decomposition, oxidation, reduction, and combination to form new compounds) are activated in the surface and bulk films. Processes involving adherence, metal solubilities, lubricant solubilities, and changes in the shear properties of the lubricants are most important.

Processes responsible for high frictional values ($f = 0.7$ to 1.6), excessive wear and galling when operation was in air at temperatures to 1700°F, are discussed and compared with various processes wherein friction may be controlled to values of less than 0.3 throughout the 100°F to 1700°F range.

SOLID FILM LUBRICANT COMPOSITIONS FOR USE AT HIGH SLIDING VELOCITIES IN LIQUID NITROGEN, by D. W. Wisander and R. L. Johnson, NASA, Cleveland, Ohio, 60AM 6C3

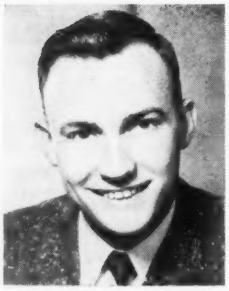
Solid lubricant coatings are of potential value for bearing and seal surfaces in cryogenic fluids. Experimental solid lubricant compositions of two types were applied to austenitic stainless steel disk specimens. Both compositions include polytetrafluoroethylene (PTFE) as the lubricant, a modified epoxy resin as a bonding agent, and either aluminum oxide or lithium aluminum silicate to match the thermal expansion of the film with the base metal. Friction and wear experiments were performed in liquid nitrogen at sliding velocities to 16,000 feet per minute and a load of 1000 grams with 3/16-inch radius hemisphere rider specimens of materials having varied thermal conductivity. Five percent PTFE is sufficient to give low friction coefficient (0.12 to 0.03) and acceptable wear. Endurance life is improved with rider materials of greater thermal conductivity.

J. Waitkus

Preprint no. 60AM 2B2

J. P. Wettach

Preprint no. 60AM 5C1



K. P. Zeman

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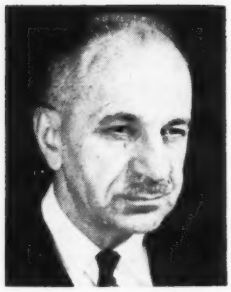

J. Zupez

Preprint no. 60AM 1B1

EXTREME-PRESSURE LUBRICATION AND WEAR—THE INFLUENCE OF CONTACT STRESS ON METALLIC WEAR, by A. Dorinson and V. E. Broman, Sinclair Research Labs., Harvey, Ill., 60AM 6C4

The wear of a steel pin terminating in a truncated 120° cone rubbing on the flat surface of a rotating disk was studied in relation to the initial contact stress. With white oil as the lubricant, three ranges of initial contact stress were employed: 152,000-157,000 psi, 67,000-76,000 psi and 47,000 psi. Typical time-dependent wear curves for the two higher pressure ranges were multistage in character, showing first a sharp rise in the amount of wear, then a levelling-off and finally transition to rapid wear again. At 47,000 psi initial contact stress, wear was a linear function of time. A compounded-extreme pressure lubricant was studied at 250,000 psi and at 148,000–156,000 psi initial contact stress. The time-dependent course of wear in these cases showed only two stages: the initial sharp rise and the levelling-off. The significance of the early phases of a metallic wear experiment with respect to the mechanism of extreme-pressure lubrication is discussed.

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OSCILLATING TANGENTIAL FORCES ON CYLINDRICAL SPECIMENS IN CONTACT AT DISPLACEMENTS WITHIN THE REGION OF NO GROSS SLIP, by R. V. Klint, G. E. Research Laboratory, Schenectady, New York, 60AM 6C5

It is shown that within the no-gross-slip region there is a well-defined region at the onset of tangential displacement within which a primarily elastic deformation is indicated. Energy dissipation studies indicate that in this region the behavior is essentially visco-elastic, confirming the results of published work. This "limit of elastic behavior" has been found and measured for a number of metallic and non-metallic materials including diamond and plastics. At amplitudes below this limit no discernible wear is observed, even after millions of cycles of rubbing. However, at larger amplitudes, wear is rapid and characteristic of fretting corrosion, especially above the gross slip amplitude. Values of elastic tangential compliance at the limit of elastic behavior are determined which are in agreement with published theoretical work. Values of the coefficient of friction beyond gross slip are found to be representative of uni-directional friction coefficients indicated in the literature. Agreement of the measured energy dissipation for the circular contact area with published theoretical values is good at the larger amplitudes near gross slip, but below the limit of elastic behavior, the agreement is poor. This is believed to be because the primary source of energy dissipation at amplitudes in the visco-elastic region is internal hysteresis of the materials.

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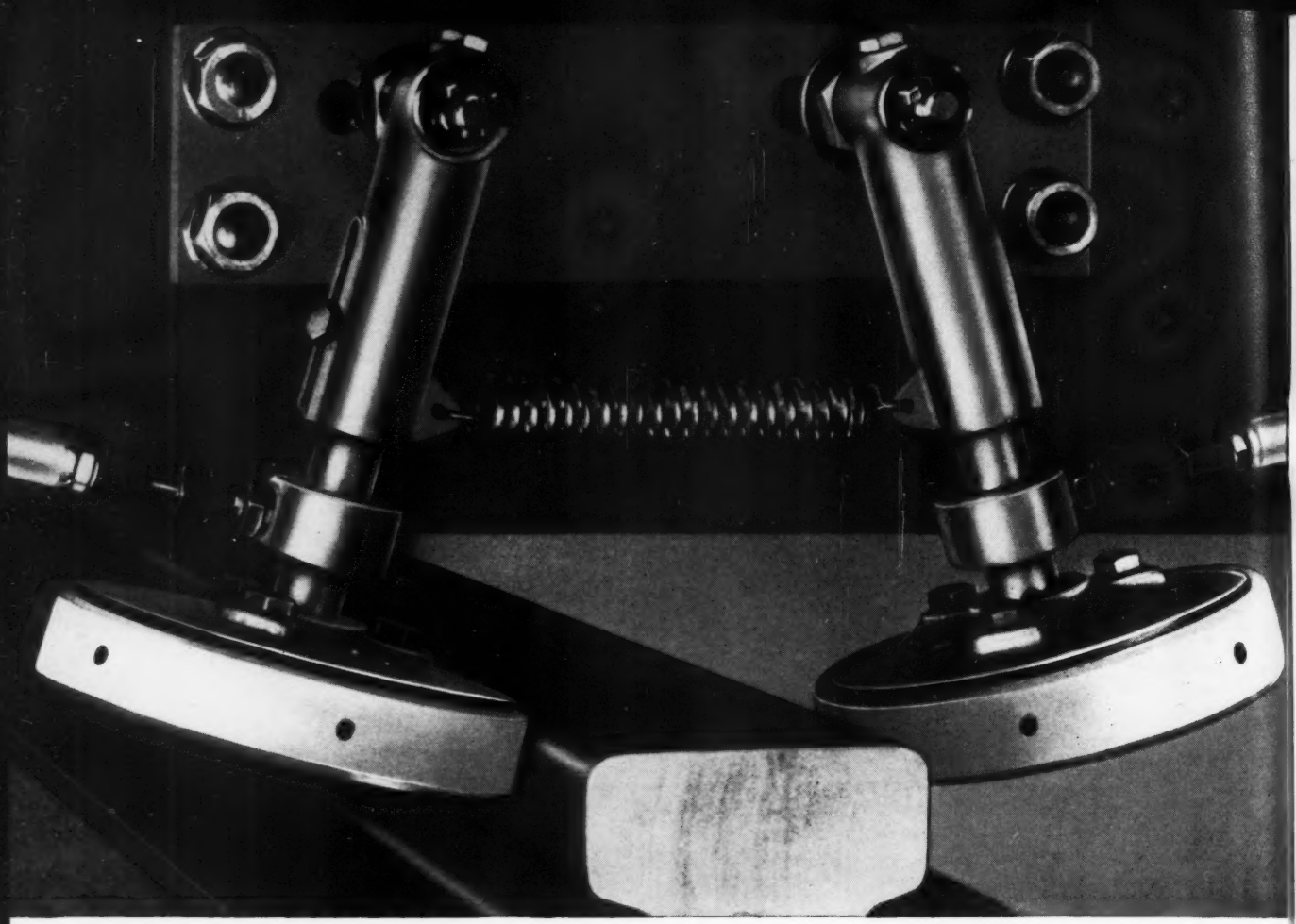

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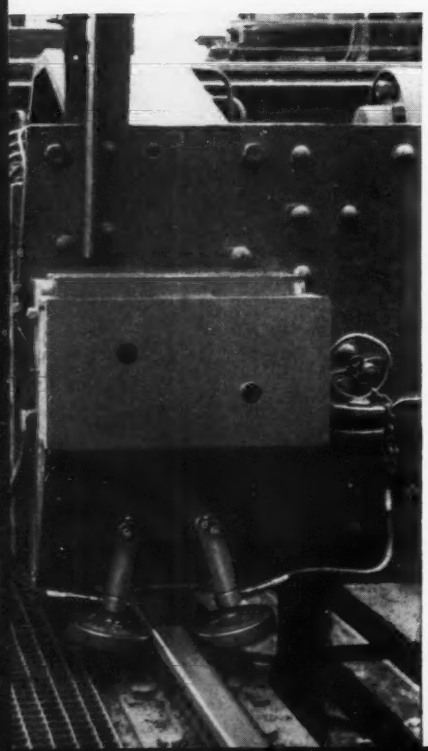

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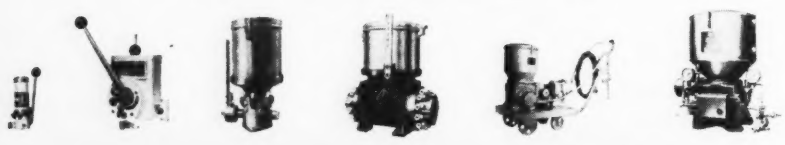

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Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

High Dropping Point Lithium Base Greases, Patent #2,872,417 (T. B. Jordan, J. P. Dilworth and J. R. Roach, assignors to The Texas Co.) A high dropping point grease comprising a lithium soap as the sole thickening agent, a liquid oleaginous lubricating base, 0.05 to 0.8 weight per cent excess lithium hydroxide over the stoichiometric required for the reaction with the soap-forming component and 0.5-5 weight per cent of a tri-C_1 to C_{15} hydrocarbon esther of phosphorus.

Rust Inhibiting Composition, Patent #2,873,-195 (M. Ganzler and G. Wachtel, assignors to Chesebrough-Pond's, Inc.) A semi-solid rust inhibiting composition consisting essentially of at least 90 per cent by weight of a petrolatum having a melting point in the range of 100 to 140F, about 0.1 to 1 per cent of an alkyl phenoxy tetraethoxyethanol in which the alkyl group contains from five to 10 carbon atoms, and over four per cent of oil-soluble petroleum sulfonates selected from the group consisting of alkali and alkaline earth sulfonates and having an average molecular weight about 400 computed as sodium sulfonate and characterized by the essential absence of water soluble sulfonate, said composition containing less than 0.5 per cent water.

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Sisal Buff Resin Impregnation Method, Patent #2,890,136 (J. L. B. Vaughan, T. W. Hislop and D. H. Hanna, assignors to Canadian Hanson and Van Winkle Co. Ltd.) A method for improving the wear resistance of a sisal buff which comprises impregnating said buff with an aqueous emulsion containing, in percentage by weight of the emulsion, about 40.0 per cent of a solid petroleum resin, about 10.0 per cent of a liquid petroleum resin and about 5.0 per cent of a nonionic emulsifier, and thereafter heating the impregnated buff to a temperature of from 70 F to about 300 F.

Sisal Buff Oil Impregnation Method, Patent #2,890,137 (J. L. B. Vaughan, T. W. Hislop and D. H. Hanna, assignors to Canadian Hanson and Van Winkle Co. Ltd.) A method for improving the wear resistance of a sisal buff which comprises impregnating said buff with an aqueous emulsion containing, in percentage by weight of the emulsion, about 27.0 per cent of heavy bodied soya bean oil and about 0.8 per cent of an emulsifying agent, and thereafter heating the impregnated buff to a temperature of from 70 F to about 300 F.

Production of Low Cold-Test Oils Using Urea, Patent #2,890,161 (J. S. Brown and A. T. Jancosek, assignors to Standard Oil Co.) In a cyclic process for treating a wax-containing hydrocarbon oil of not greater than SAE 10 viscosity and pour point above 0 degrees F and obtaining a low cold-test oil therefrom, wherein said wax-containing oil is contacted with urea in a proportion of at least about four pounds of solid urea per pound of wax contained in said oil in the presence of a liquid alkylate fraction and between about 0.5 and four gallons of aqueous methanol per 100 pounds of urea, said methanol containing between about two and ten per cent by volume of water, said contacting is continued under conditions and for a sufficient time to form urea adducts with the straight-chain waxes contained in said oil, said adducts and any unreacted urea are separated from the resulting slurry, said liquid alkylate fraction is stripped from the treated liquid resulting therefrom, whereby the desired low cold-test oil is obtained having a pour point substantially below 0 degrees F, said urea adducts are decomposed by contact with a quantity of said liquid alkylate fraction at elevated temperature below the melting point of urea, whereby said straight-chain waxes are liberated and dissolved in said alkylate fraction and urea is regenerated in solid form, and said regenerated urea is recovered and used to contact additional charging stock, the improvement which comprises retaining activating proportions of methanol and water on the regenerated urea by decomposing the urea adducts in the presence of a liquid alkylate fraction and at a temperature between about 155 and 170 F, said temperature being above the decomposition temperature of the urea adducts and below the liberation temperature of the retained methanol and water, and regenerating the urea in a finely divided highly active form for treating additional charging stock with said activating proportions of methanol and water retained on the urea.

Organosiloxane Greases, Patent #2,890,-170 (W. H. Ragborg, assignor to Dow Corning Corp.) A grease composition consisting essentially of a major proportion of an organosiloxane fluid, a grease thickening agent in an amount sufficient to thicken said fluid to the consistency of a grease, and from 0.01 to 0.1 inclusive per cent by weight of benzotriazole based on the weight of the organosiloxane.

Extreme High Temperature Grease Compositions Gelled with Thermosetting Resin-Coated Gels, Patent #2,890,171 (J. W. Armstrong and J. A. Edgar, assignors to Shell Development Co.) A lubricating grease composition consisting essentially of a liquid organo-silicone polymer the organo radicals of which are selected from the group consisting of C_{1-8} alkyl and C_{1-8} oxyalkyl radicals, said polymer being of lubricating oil viscosity thickened to a grease consistency with from about 1 per cent to about 20 per cent by weight of a colloidally dispersed clay, the surfaces of said clay bearing from about 1 per cent to about 20 per cent, based on the weight of the clay, of a thermally resinified thermosetting resin of the

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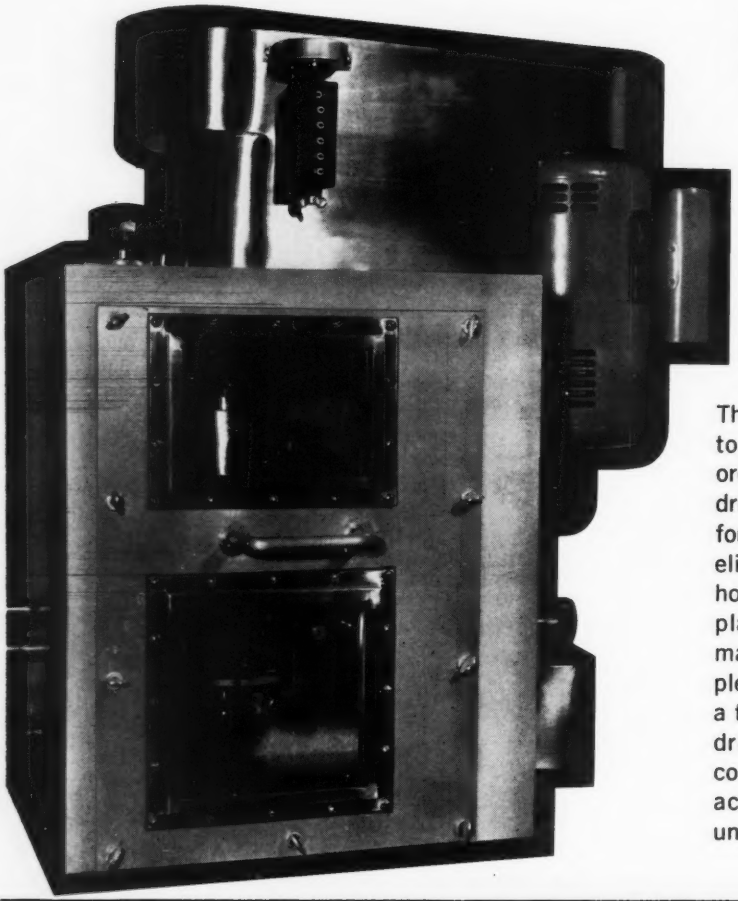

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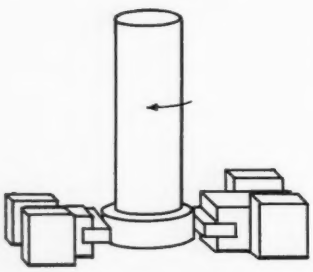

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group consisting of phenoplasts formed between an aldehyde and a phenol in a phenol:aldehyde molar ratio between 1:1 and 1:1.5 and aminoplasts formed between an amine and an aldehyde in an amine: aldehyde molar ratio between 1:1.5 and 1:6, the solvent-soluble resin being mixed with the clay and oil and thereafter heated in the presence thereof to form the solvent-insoluble resin.

Soluble Oil Compositions of Improved Emulsification and Dispersion at Low Temperatures, Patent #2,890,172 (A. A. Manteuffel and G. R. Cook, assignors to The Pure Oil Co.) A soluble oil blend comprising about 30.0 to 3.0 weight per cent of an alkali metal petroleum sulfonate emulsifier, about 2.0 to 4.0 weight per cent of a mixture comprising rosin acids and fatty acids, about 0.4 to 5.0 weight per cent of an alcoholic coupling agent, about 0.3 to 1.0 weight per cent of alkali selected from the group consisting of sodium hydroxide and potassium hydroxide, about 0.5 to 2.0 weight per cent of water, about 0.2 to 0.5 weight per cent of a chlorinated wax-phenol condensation product and about 57.5 to 93.6 weight per cent of aromatic solvent extract from the manufacture of a mineral lubricating oil.

Improving Color of Lubricating Oils and Waxes, Patent #2,890,963 (J. Van Dyck Fear, assignor to Sun Oil Co.) A process for producing waxes which comprises catalytically cracking a gas oil boiling between about 500 F and 1100 F, segregating a wax-containing fraction from the cracked products, admixing with said fraction at least 3 per cent of its volume of a hydrocarbon fraction essentially all of which boils above the end point of the wax-containing fraction, fractionally distilling the mixture, recovering an overhead product approximately equal in volume to the wax-containing fraction, and segregating wax from the overhead product.

Lubricant Composition, Patent #2,892,786 (W. T. Stewart, F. A. Stuart and W. Lowe, assignors to california Resarch Corp.) A lubricant composition comprising a major portion of an oil of lubricating viscosity and a minor portion sufficient to enhance the detergent characteristics of the composition of a copolymer of monomers selected from at least each of the first two classes of the classes consisting of (A) polymerizable oil-solubilizing compounds having a single ethylenic linkage and containing a monovalent hydrocarbon group of from eight to 30 carbon atoms, (B) nitrogenous compounds selected from the group consisting of amides and amine salts of alpha, beta-ethylenically unsaturated monocarboxylic acids of from three to six carbon atoms and alpha, beta-ethylenically unsaturated-alpha, beta-dicarboxylic acids of from four to 12 carbon atoms each in which the alkyl groups contain from one to four carbon atoms each, wherein the amide and amine salt nitrogen atom is attached to a substituted aliphatic hydrocarbon group of from two to seven atoms substituted by at least one hydroxyl group, and (C) acidic compounds selected from the group consisting of alpha, beta-ethylenically unsaturated monocarboxylic acids of from three to six carbon atoms, alpha, beta-ethylenically unsaturated alpha, beta-dicarboxylic acids of from four to to 12 carbon atoms in which the alkyl groups contain from one to four carbon atoms each and anyhdrides, half-amides and monoamine salts of said dicarboxylic acids wherein the amide and amine salt nitrogen atom is attached to an aliphatic hydrocarbon group as defined in (B), said copolymer having a molecular weight of at least 2,000 and said monomers being present in the copolymer in the ratio of from about one to 20 monomer units of the oil-solubilizing monomer (A) for each monomer unit of the nitrogenous monomer (B) and the acidic compound (C).

Patent Nos. 2,892,788 by W. T. Stewart, F. A. Stewart and W. Lowe; #2,892,790 by F. A. Stuart, W. T. Stewart and W. Lowe; #2,892,791 by W. Lowe, W. T. Stewart and F. A. Stuart; #2,892,792 by W. T. Stewart, F. A. Stuart and W. Lowe; and #2,892,793 by W. T. Stewart, D. R. Wilgus and F. A. Stuart, all captioned "Lubricant Composition" and assigned to California Research Corp. are similar to Patent Nos. 2,892,783 and 2,892,786.

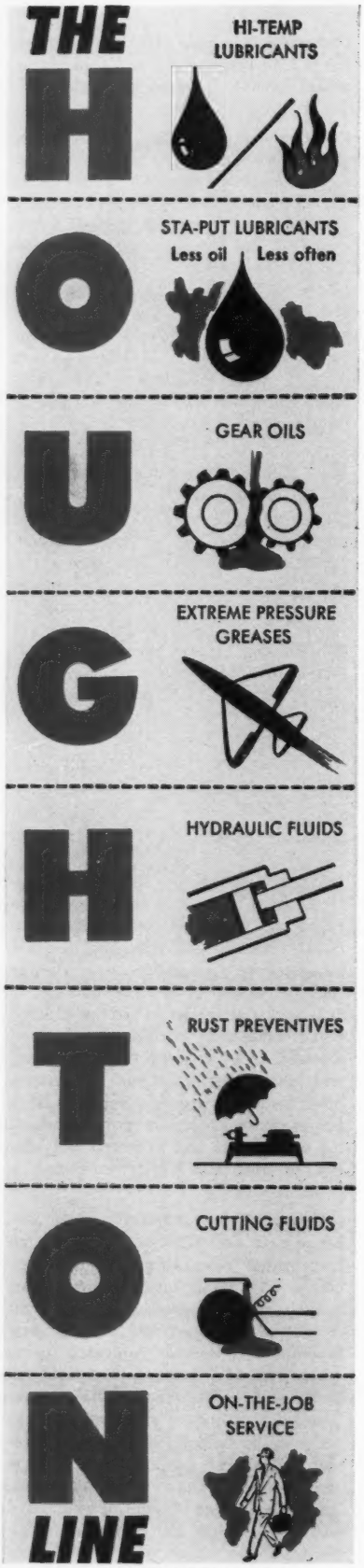
Lubricating Oil Compositions, Patent #2,889,282 (L. E. Lorensen, E. R. Barnum and J. Zachar, assignors to Shell Development Co.) A mineral lubricating oil composition comprising a major amount of a mineral lubricating oil and a minor amount sufficient to effectively depress the pour point of the oil and improve its detergent properties, of an oil-soluble copolymer of (1) a monovinyl-substituted pyridine of the group consisting of pyridines substituted on one of the ring carbon atoms with, as the sole substituted substituent, a vinyl group, and derivatives of the aforedescribed vinyl pyridines having a lower alkyl group substituted on a ring carbon atom and (2) a mixture of a C_{16} to C_{20} alkyl ester of an acrylic acid of the group consisting of acrylic acid and methacrylic acid and a C_{10} to C_{14} alkyl ester of an acrylic acid of the group consisting of acrylic acid and methacrylic acid in mole ratios varying from 1:4 to 4:1, said copolymer having the monovinyl pyridine and the combined acrylic acid esters in a mole ratio varying from 1:2 to 1:10, respectively, and a molecular weight from 5×10^4 to 2.5×10^6.

Multi-Functional Lubricating Oil Additives, Patent #2,832,737 (J. R. Roach and J. R. Morris, assignors to The Texas Co.) A lubricant composition comprising a major proportion of a mineral lubricating oil and between one and two per cent by weight of a mixture of about two parts of the magnesium salt of N, N-1-dialkyl dithiocarbamyl acetic acid wherein said alkyl group has from four to 12 carbon atoms, and about one part of zinc alkyl salicylate wherein said alkyl group has an average of from 20 to 30 carbon atoms.

Mixed Sodium-Calcium Roller Bearing Grease, Patent #2,832,738 (R. F. Nelson, assignor to The Texas Co.) A high dropping point roller bearing grease comprising an oleaginous lubricating base as the major component, a mixed sodium-calcium soap of a mixture comprising 35 to 70 per cent hydrogenated castor oil and 30 to 65 per cent of soap precursor selected from the group consisting of 12-hydroxy stearic acid, lower monoalkyl esters of said 12-hydroxy stearic acid and mixtures thereof, the sodium to calcium soap ratio being between 3.5:1 and 8:1 in said mixed soap.

Lubricating Compositions, Patent #2,832,740 (W. D. Garden and J. S. McFarlane, assignors to Imperial Chemical Industries Limited) A lubricating composition consisting essentially of at least one liquid organopolysiloxane and a minor proportion, not exceeding about five per cent by weight of the polysiloxane, of at least one derivative of orthophosphoric acid wherein one hydrogen atom only is replaced by a paratert.octylphenyl group and wherein at least one of the two other hydrogen atoms is replaced by a non-unsaturated organo group containing only carbon and hydrogen and having not more than 9 hydrogen atoms.

Soluble Oil, Patent #2,832,736 (J. L. Jezl, assignor to Sun Oil Co.) A soluble oil composition comprising: mineral lubrication oil; alkali metal soap of carboxylic acids obtained by partial oxidation of mineral oil, the carboxyl saponification number equivalent being within the range from ten to twenty mg of KOH per gram; alkali metal soap of petroleum mahogany sulfonic acids, the sulfonate saponification number equivalent being within the approximate range from three to ten mg of KOH per gram; 2.25 to 5.0 volume per cent of water; and 1.25 to 3.0 volume per cent of an alkylphenyl mono ether of a polyethylene glycol, the alkylphenyl radical having its aromatic nucleus directly attached to



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the oxygen atom of the terminal ether linkage of the polyethylene glycol radical, said alkylphenyl radical containing x carbon atoms, x being an integer in the range from 11 to 28 inclusive, said ether containing n ethylene glycol units in the molecule, n being a positive integer from four to 21 inclusive and within the range from (x—8) to (x—2) inclusive.

Complex Ester Synthetic Lubricant, Patent #2,831,813 (A. H. Matuszak and J. K. Appeldoorn, assignors to Esso Research & Engineering Co.) A synthetic lubricating oil having outstanding lubricating characteristics at both high and low temperatures which comprises a complex ester.

Spindle Oil Composition, Patent #2,830,951 (J. N. Bowden and E. W. Brennan, assignors to The Pure Oil Co.) A lubricating oil comprising a major amount of mineral lubricating oil containing not less than 0.3 per cent by weight of methyl ricinoleate and tetramethyl diamino diphenyl methane in an amount to cooperate synergistically with said methyl ricinoleate to increase the load bearing capacity of said oil, the ratio of methyl ricinoleate to tetramethyl amino diphenyl methane being about 5:1.

Polyamide Grease Composition, Patent #2,830,954 (J. A. Dixon, assignor to California Research Corp.) A grease composition comprising a major proportion of a lubricating oil and, in an amount sufficient to thicken said lubricating oil to the consistency of a grease, a grease thickening agent obtained by first forming a polyamide having terminal amine groups by reacting aliphatic dibasic acids containing from four to 12 carbon atoms and aliphatic diamines containing from two to 22 carbon atoms, wherein the mol ratio of said dibasic acids to said diamines has a value from 0.25 to 0.75, followed by reacting the resulting polyamide with aliphatic monocarboxylic acids containing from three to 23 carbon atoms in an amount sufficient to form an amide with the residual amine groups of said polyamide, the resulting grease thickening agent having a molecular weight less than 1000.

Polyamide-Thickened Grease, Patent #2,830,955 (J. A. Dixon, assignor to California Research Corp.) A grease composition comprising a major proportion of a lubricating oil and, in an amount sufficient to thicken said lubricating oil to the consistency of a grease, a grease thickening agent obtained by first forming a polyamide having terminal carboxylic acid groups by reacting aliphatic dibasic acids containing from four to 12 carbon atoms and aliphatic diamines containing from two to 22 carbon atoms, wherein the mol ratio of said dibasic acids to said diamines has a value from 1.5 to four, followed by reacting the resulting polyamide with n-primary amines containing from two to 22 carbon atoms in an amount sufficient to form an amide with the residual acid groups of said polyamide, the resulting grease thickening agent having a molecular weight less than 1000.

Hydraulic Power Transmission Fluids, Patent #2,830,956 (J. I. Wasson, D. L. Bonham and W. C. Howell, Jr., assignors to Esso Research & Engineering Co.) A hydraulic transmission fluid having a viscosity in the range of 34 to 60 ssu at 210 F, a viscosity index above 130, a flash point above 300 F, and a pour point below —20 F, and comprising 75-85 wt per cent of a mineral lubricating oil, 7-15 wt per cent of a shear stable polymeric viscosity index improver selected from the group consisting of polybutene and polymethacrylates, 0.2-1 wt per cent of a vinyl acetate copolymer pour point depressor, up to 0.4 wt per cent of an alkylated phenol oxidation inhibitor, 0.1-0.5 wt per cent of a sulfurized olefinic hydrocarbon corrosion inhibitor, 0.5-4.0 wt. per cent of a detergent inhibitor selected from the group consisting of metal salts of alkylated phenol sulfides and petroleum sulfonates, 1-5 wt per cent of sulfurized sperm oil, and 0.1-1 wt per cent of a fatty acid having from 14 to 22 carbon atoms, said sperm oil and fatty acid totaling 1.5-6 wt per cent of said fluid.

Onium Clay Grease Containing Surface Active Agent, Patent #2,831,809 (W. H. Peterson, assignor to Shell Development Co.) A grease composition comprising a major proportion of a mineral lubricating oil having colloidally dispersed therein a gelling proportion of an organophilic bentonite originally exhibiting a base-exchange capacity of at least 60, in which the exchangeable inorganic cation has been exchanged for an ammonium base having at least one aliphatic radical containing between 14 and 18 carbon atoms in a chain, from about 0.5 per cent to about 20 per cent by weight, based on the organophilic bentonite of an oleophilic polyamino oxy compound containing at least three nitrogen atoms and oxy groups together spaced apart in the molecule by not more than ten carbon atoms, from about one per cent to about 20 per cent by weight, based on the organophilic bentonite, of an inorganic nitrite and from about one per cent to about 20 per cent by weight based on the organophilic bentonite, of an alkaline earth metal hydroxide.

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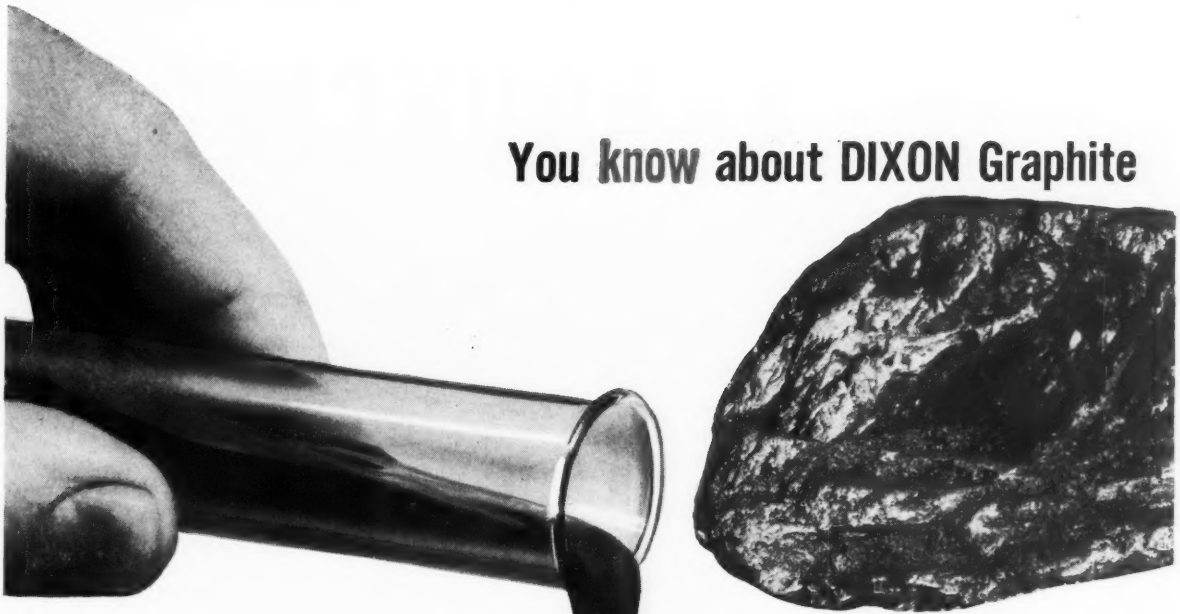

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"Composition Bearings Used in Rolling Mills" by K. E. McHenry

The past 25 years or so have seen a definite trend towards widespread usage of non-metallic composition bearing materials which can function primarily on water lubrication. The foundation of such materials consists essentially of layers of fine weave cotton duck, or single ply woven cotton cord duck. These fabrics are impregnated with phenol-type synthetic resins until they contain about half their weight of solid resin; they are then laminated to the required thickness and molded to shape.

Certain very distinctive properties are possessed by composition bearings. These must be carefully considered when incorporating such materials in operating machinery. e.g.

1—*Impact and compressive strengths.* The former indicates the ability to resist cracking upon journal impact. The latter (averaging around 40,000 psi. measured perpendicular to the laminations) indicates the load-carrying capacity. Such bearing materials are usable for loads up to 6000 psi. taking into consideration the rubbing speed, clearance, type of load and method of lubrication.

2—*Effect of fluid lubricants upon absorption and expansion.* Some expansion occurs due to absorption. This is compensated for in design by providing expansion space in every direction except in the backing area where retention of the original dimensions is important. In other respects clearances can be the same as for metallic bearings for similar service conditions. Thermal expansion is virtually negligible.

3—*Thermal conductivity.* Since composition bearings are poor heat conductors, any generated or transmitted heat must be carried away by the lubricant. Hence the value of water lubrication. Good heat transfer is very important to prevent charring of the material.

4—*Stability.* The resistance to chemical attack varies somewhat according to grade and type. Mild acid solutions and hot strong alkaline solutions are most destructive. On the other hand composition materials are very resistant to hydrocarbon solvents and lubricants.

5—*Coefficient of friction* varies according to speed and load: high for slow speeds and heavy loads; low for high speed and light loads.

6—*Resiliency,* excellent. Generally higher than for most metallic bearing materials. Due to cushioning ability they are successfully applied where high shock loading prevails.

Since composition bearings are essentially water lubricated, the type, temperature, source and means of circulation of the water supply is most important. It must be clean, free from abrasives, and sufficiently cool to serve both as collant as well as lubricant; also adequate volume must be available as this relates directly to the heat transfer effect. Normally the maximum accepted temperature is around 135° Fahr. in steel roll neck service. In application, splash or turbulence must be avoided as this reduces the cooling and lubricating effect. Installations, therefore, must be studied with regard to method of delivery and point of application of water in order to insure adequate unrestricted flow; so that the water stays on the exposed revolving surfaces as long as possible. In any event the bearing water supply should involve a separate system, apart from the general mill or plant system so that flow control can be regulated irrespective of other plant needs.

Effective lubrication is indicated by the color of bearing and journal. Dark brown signifies satisfactory lubrication. Light yellow, rough bearing surface and bright or light grey journals suggest inadequate protection. If either bearing or journal surface is scored or ridged, the trouble can be traced to scale or dirty water.

While water predominates as the lubricant, certain conditions such as rubbing speeds below 200 fpm., will call for supplementary grease or oil lubrication, in conjunction with water for cooling. Also roll necks and journals should be swabbed or sprayed with with lubricating oil during shut-down periods to prevent rusting and to minimize subsequent bearing wear. Some installations have automatic spray attachments for oil injection just before shut-down, also preceeding starting up. (*Digested by A. F. Brewer*)

"Behavior of Viscosity Index Improvers in Lubricating Oils," Robert Byrne, Association of American Railroads, Chicago, Illinois.

An investigation was conducted into the use of extremely long chained polymeric materials to improve the viscosity temperature characteristics of lubricating oils.

The coefficient of viscosity of liquids can be defined in terms of viscous flow involving the movement of molecules from lattice sites of higher potential to sites of lower potential. On such a basis, the temperature coefficient of viscosity depends upon the factors which influence the relative degrees of freedom of the molecule in the body of the liquid. The pressure coefficient of viscosity is a measure of the hole which must be formed to allow flow to occur or to allow a molecule to transfer from one lattic site to another. In the case of larger molecules, the pressure coefficient is a measure of the effective molecular size or chain length that must be available for flow to occur.

The laboratory measurement of viscosity is generally obtained by the use of low shear instruments. Kinematic viscosity values for temperatures other than the experimental temperatures are often obtained through the use of ASTM charts based on the Walther equation for viscosity. The concept of specific viscosity as introduced by Staudinger has been utilized by Horowitz to formulate viscosity temperature relationships for blends of polymers in oil and also to permit estimation of kinematic viscosity for temperatures other than the experimental temperatures.

Measured kinematic viscosity values for a typical V. I. improved oil at temperatures of 150F, 50F and 0 F were compared with predicted values obtained using experimental values at 100F and 210F by (a) extrapolation using the ASTM charts, (b) by calculation using the Horowitz equation. Agreement existed between the experimental and calculated data throughout the temperature range studied, whereas the extrapolated data did not correlate in the lower temperature regions.

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TECHNICAL DIGEST

(*Con't. from page 191*)

Analysis of polymeric materials in oil suggests that the viscosity can be affected by two mechanisms involving the shear rate.

A temporary change in viscosity can occur during the application of shearing forces to blends of a base oil and a viscosity index improver. For such materials the viscosity obtained under high shear rates can be considerably less than the value obtained at the same temperature in a low rate of shear instrument. As the shear rate is continually increased the viscosity of the blend approaches that of the base oil. This loss in viscosity under high shear forces is due to orientation of the long chained polymer in the direction of flow and shearing force, thereby offering less effective volume for the inhibition of bulk flow. Experimental data show the sharp reduction in viscosity that is obtained at shear rates as low as 1000 reciprocal seconds.

A permanent viscosity loss can occur during the shearing of oils containing long chained polymer viscosity index improvers. The shearing action in this case reduces the chain size through rupture of the molecule thus leading to a reduction in viscosity of the polymer-oil blend. A series of oils containing various concentrations of commercial V. I. improvers were studied to determine the permanent change in viscosity of the blends that occurs during high speed operation. The oils were evaluated on a test apparatus that consisted of a 5-½ x ten inch railroad journal and bearing operated at 500 rpm under a load of 6000 pounds. The journal was lubricated with a four roll waste pack and samples of oil were taken from the journal surface at selected time intervals. The various viscosity index improvers were found to differ in their ability to resist permanent loss of viscosity under the high shear rates imposed. (*Digested by H. J. Connors*)

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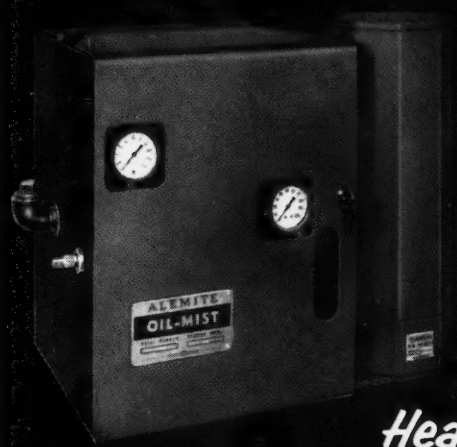

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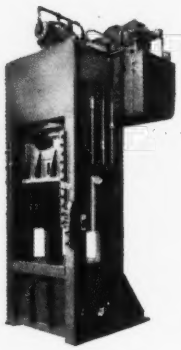

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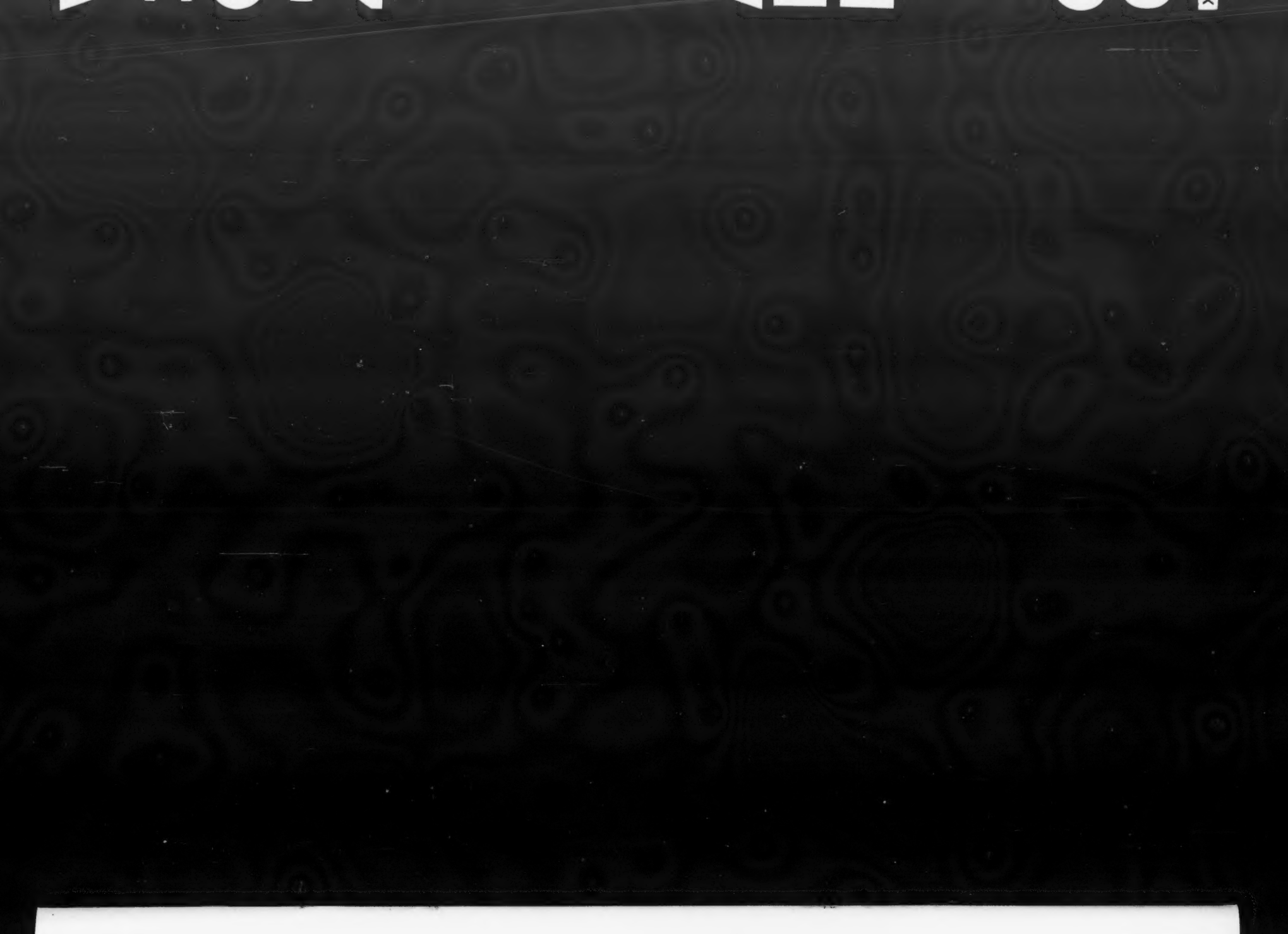
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